National Elevation Dataset

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USGS

The National Elevation Dataset (NED)

- Seamless national coverage of “best available” raster elevation data
  - Geographic “projection”
  - 1-arc-second (30-meter), 1/3-arc-second (10-meter), and 1/9-arc-second (3-meter) grid spacing
    - Alaska: 2-arc-second grid spacing
  - Datum: NAD 83 horizontal; NAVD 88 vertical
  - Elevation units: decimal meters
  - Updated bi-monthly to incorporate all new USGS DEM production and other newly available source data
- NED is the elevation layer of *The National Map*

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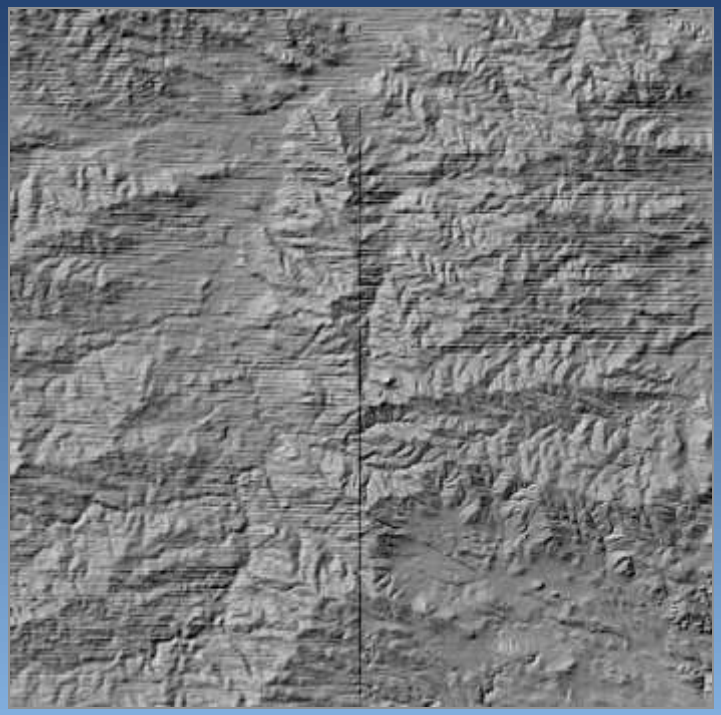
Large-Area Elevation Data Coverage



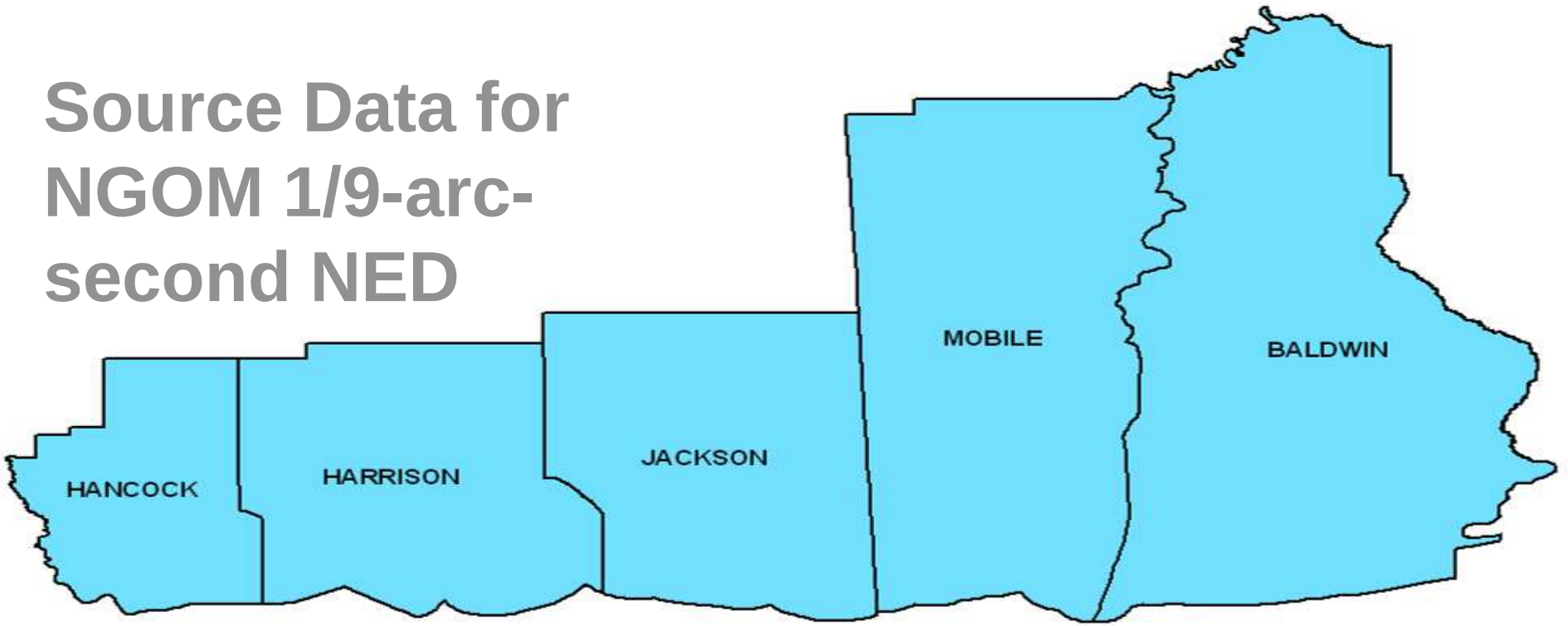
7.5-minute quadrangle tiled database

- Nearly 54,000 quad-based DEMs
- Projected in 10 different UTM zones
- Production artifacts (stripes), slivers of missing data, elevation value mismatches along quad boundaries
- Metadata in individual files

The National Elevation Dataset (NED)

- Seamless raster mosaic
- Consistent national coordinate system
- Standardized datums and units
- Filtered and edge-matched, where necessary
- Spatially referenced metadata

Source Data for NGOM 1/9-arc-second NED



Area	Format	Projection	Elevation Units	Metadata?
Louisiana	5-m DEM (raster)	UTM	Feet	Yes
Hancock Co., Misissippi	LAS binary (points)	MS State Plane (m)	Feet	Yes
Harrison Co., Mississippi	ASCII XYZ (points)	MS State Plane (ft)	Meters	No
Jackson Co., Mississippi	LAS binary (points)	MS State Plane (m)	Feet	Yes
Mobile Co., Alabama	LAS binary (points)	AL State Plane (ft)	Feet	Partial
Baldwin Co., Alabama	Shapefile (MPBL)	AL State Plane (ft)	Meters	Partial

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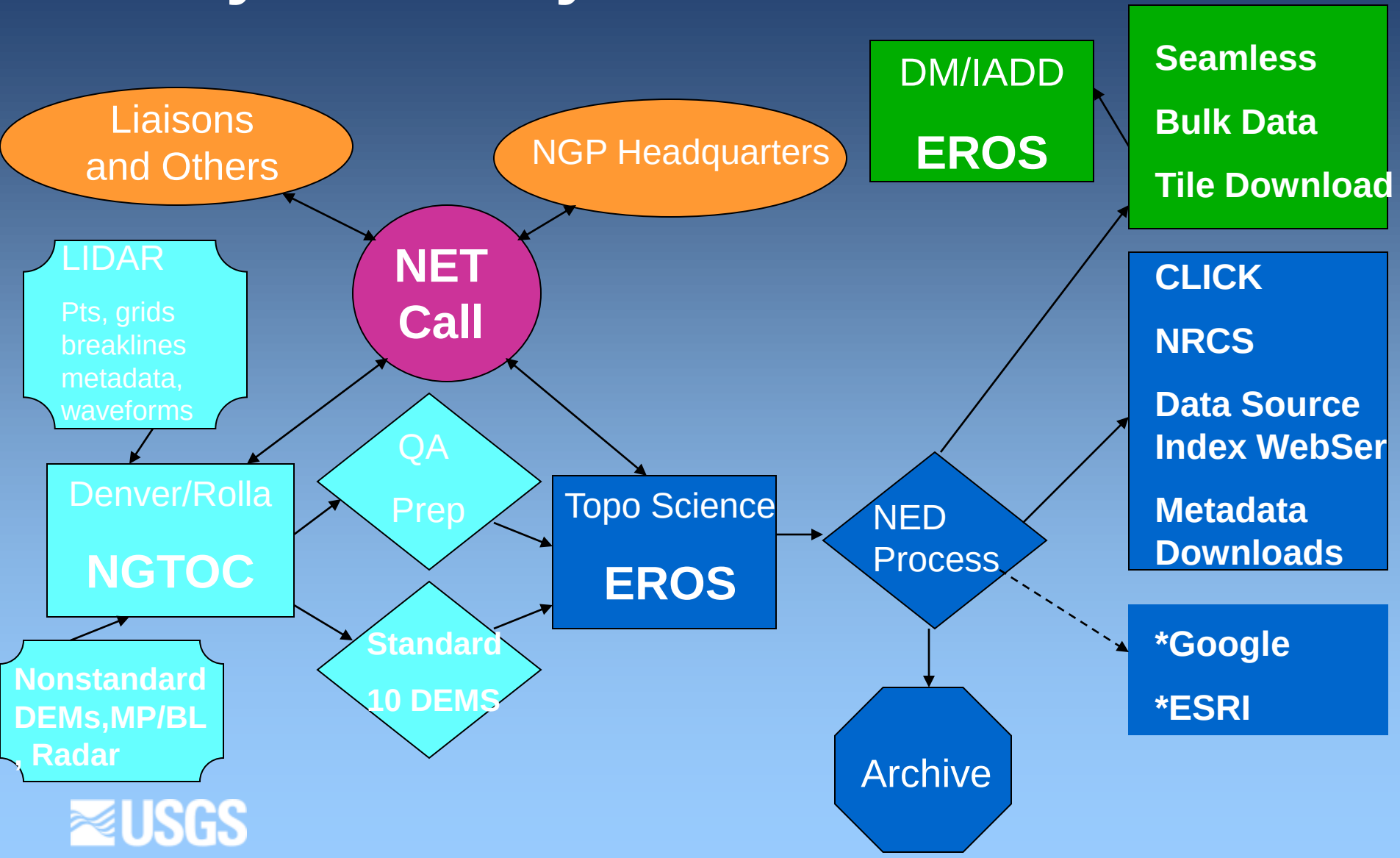
Analysis Ready NED



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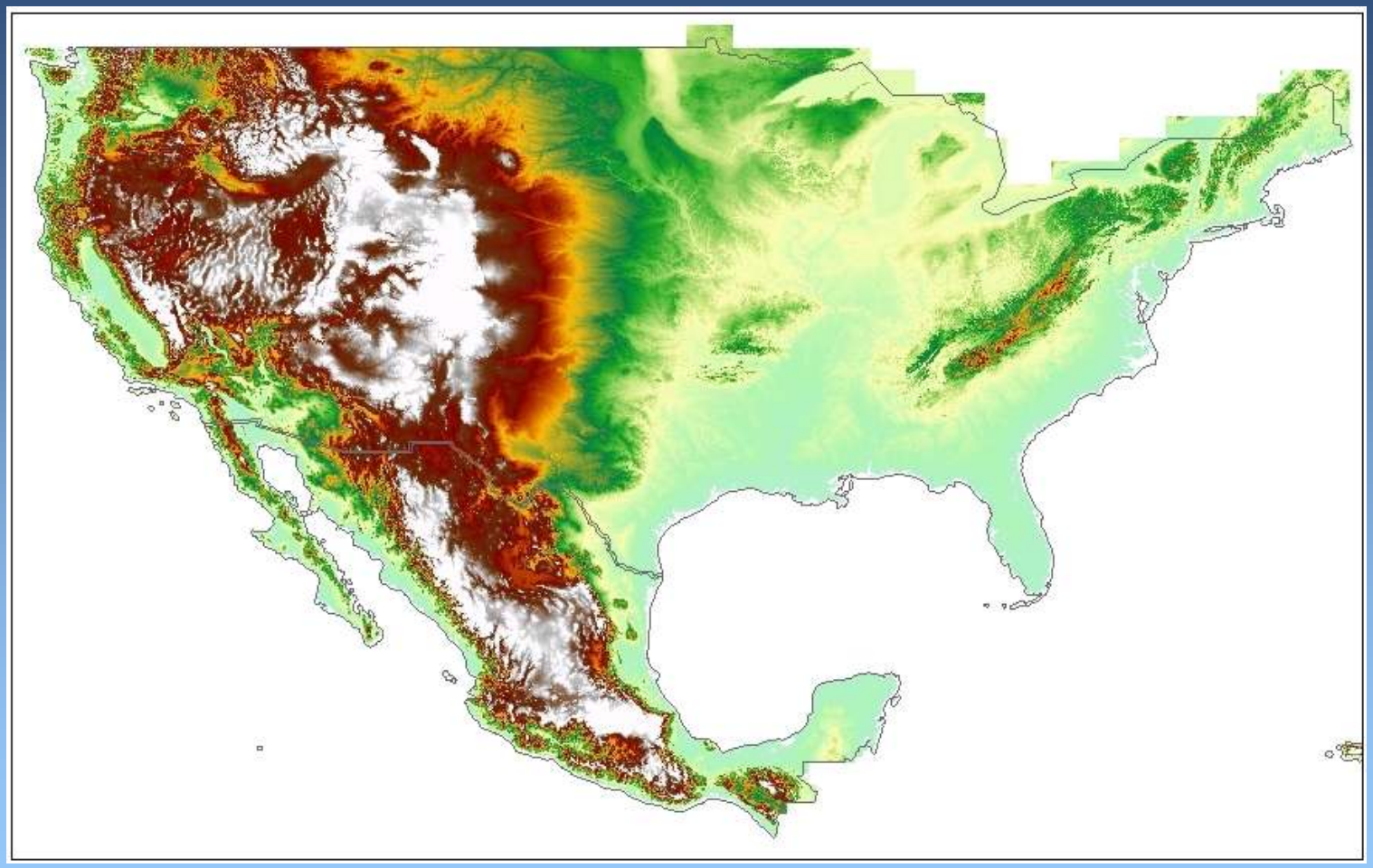
* New Distribution Possibility

NED 1-arc-second



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1-arc-second layer is approximately 30 meter resolution

- Processed as 1 degree titles and merged into a seamless mosaic
- Covers Conterminous U.S., Hawaii, small areas of Alaska, Territorial Islands of the US and Mexico
- Many applications are more suited for the 1-arc-second layer
  - Smaller size
  - Faster to download and process
- Relatively low cost to prepare and store
- Makes possible an inexpensive seamless continental view of North America
- Entire country of Mexico was added in 2009
- Negotiations are underway for the possible inclusion of part of Canada

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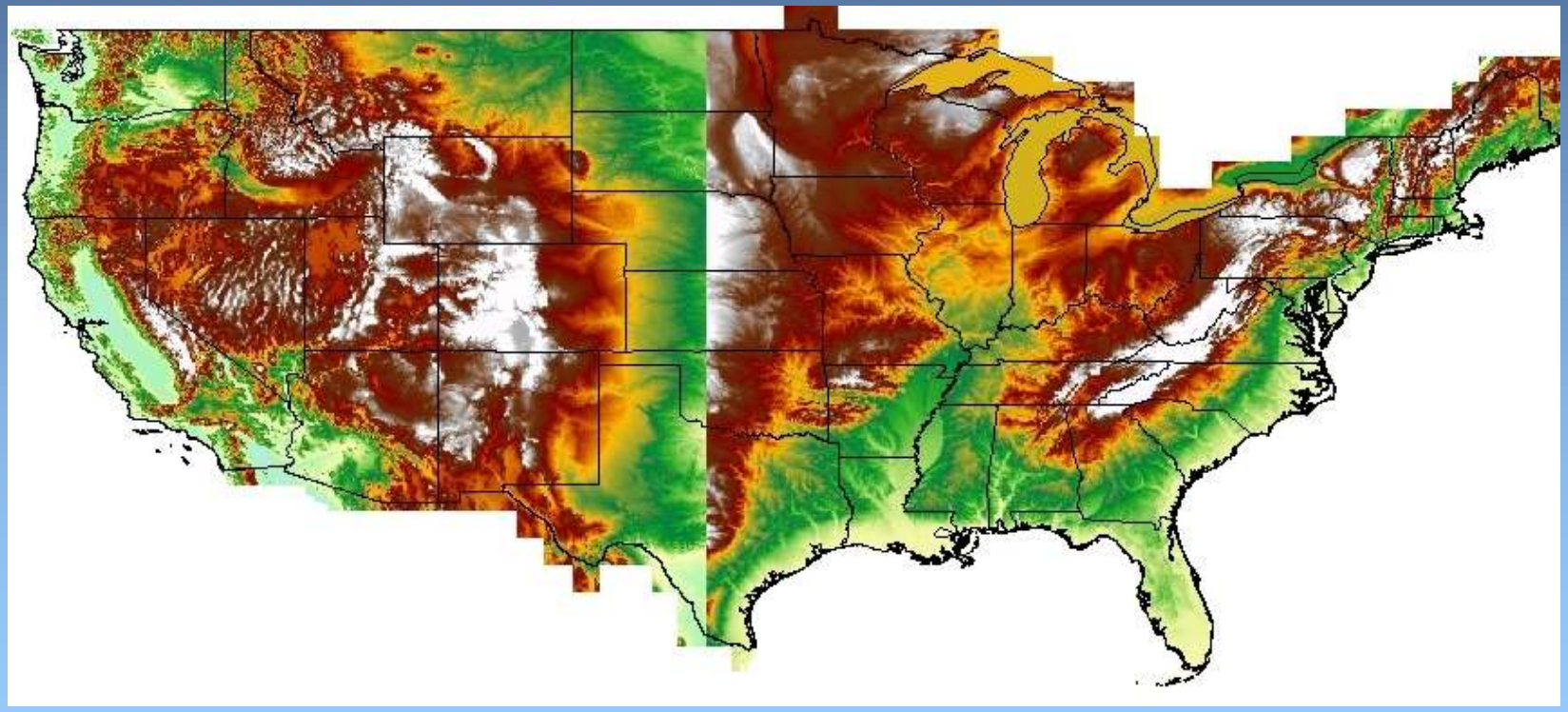
- NED 1/3-arc-second layer is approximately 10 meter resolution and is often referred to as 10 meter NED.
  - Processed as 1 degree tiles
  - Merged into two part seamless mosaic
  - Covers conterminous US, Hawaii, and small areas of Alaska and the Territorial Islands
  - 90% is 10 meter or better source



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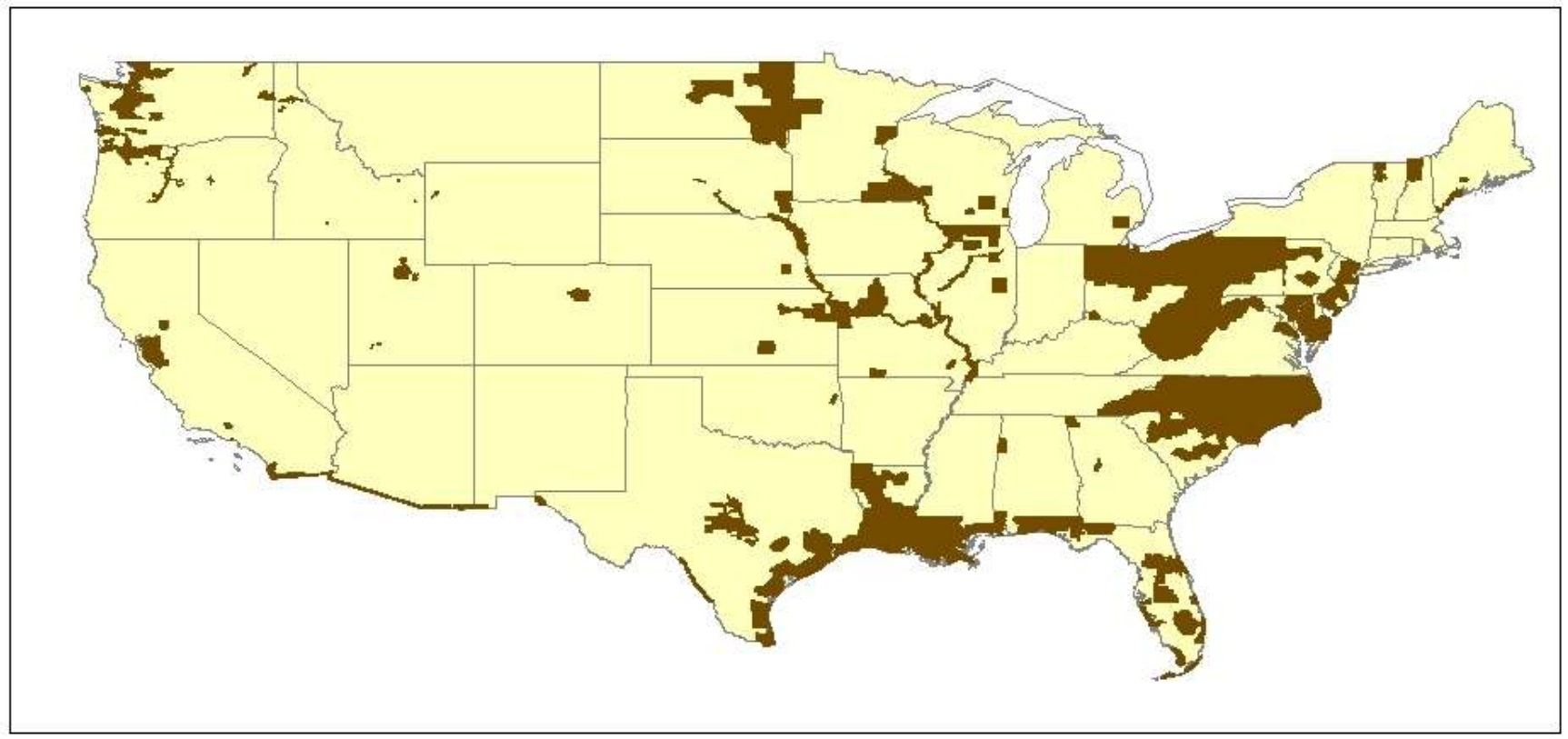
- High resolution or 1/9-arc-second data or approximately 3 meters dataset
  - Mostly of lidar source
  - Processed on a project basis and edge compared with other projects
  - Inserted into ArcSDE as areas or projects rather than one or two mosaics
  - Covers about 10% of the contiguous US



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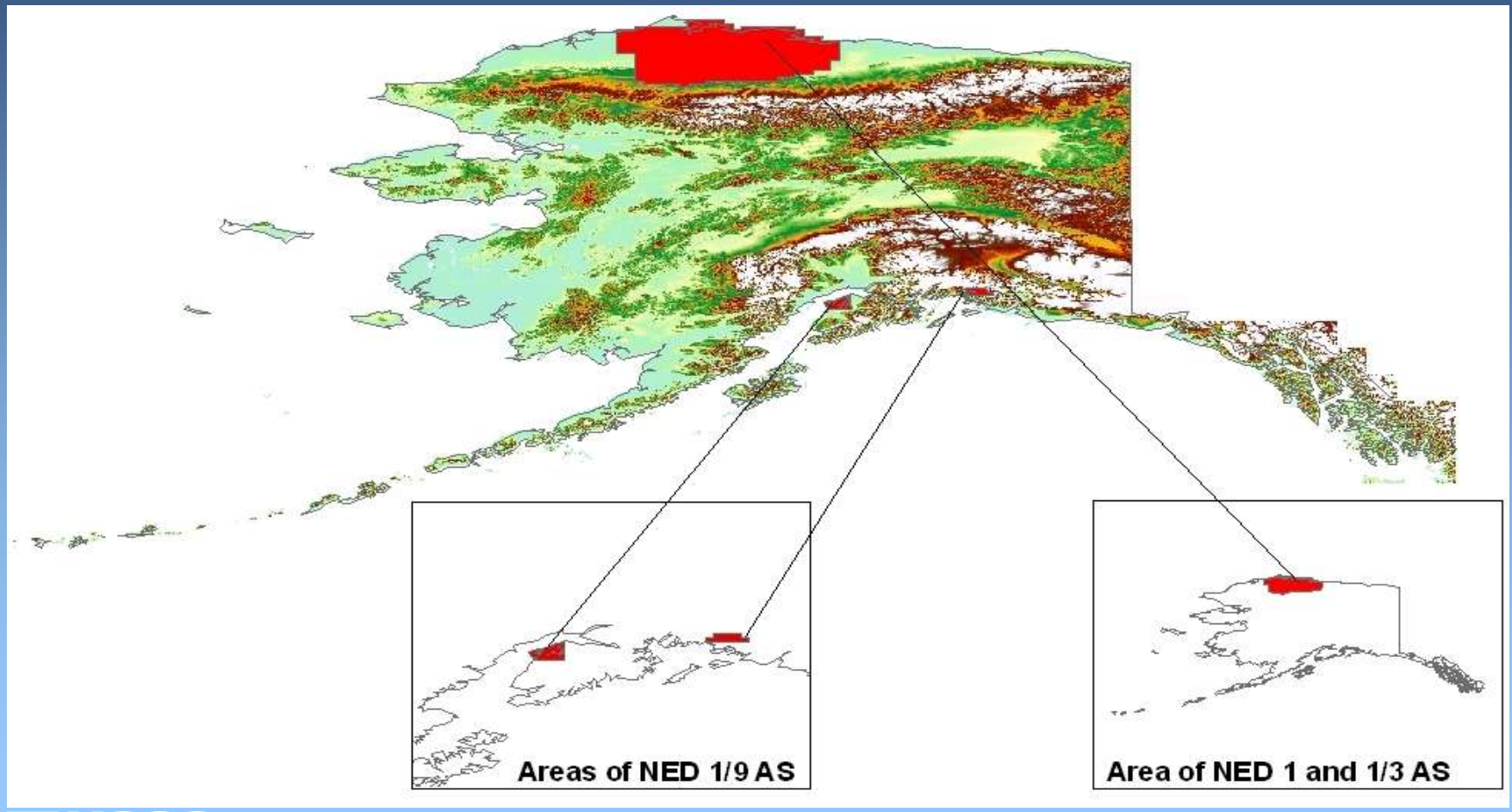
- 2-Arc-Second Resolution Approximately 60 meters
  - The best available source for Alaska
  - No update of 2-arc-second data
  - Improvement through migration of higher resolution data



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Possible NED 1/27-arc-second layer

- Much of the lidar source data would support a 27th or approximately 1 meter dataset
- Customers are asking for it
- Present NED model was developed for the 1-arc-second and is being stretched by the NED 1/9 processing and is not appropriate the NED 1/27th layer
- Storage for 1-arc-second layer of the contiguous US is about 45 GB for 1/27 would be about 33,000 GB
- Benefits of being uniform (standard projection and resolution) may be outweighed the possibility of data corruption at this high of resolution
- Research would be beneficial to determine pros and cons

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NED 1/27-arc-second

- **Short term solution possibility:**
  - **Load and serve this data in the original projection and resolution as a special collection**

- **Forward looking possibility:**
  - **Cloud Computing would be a better platform for future growth**

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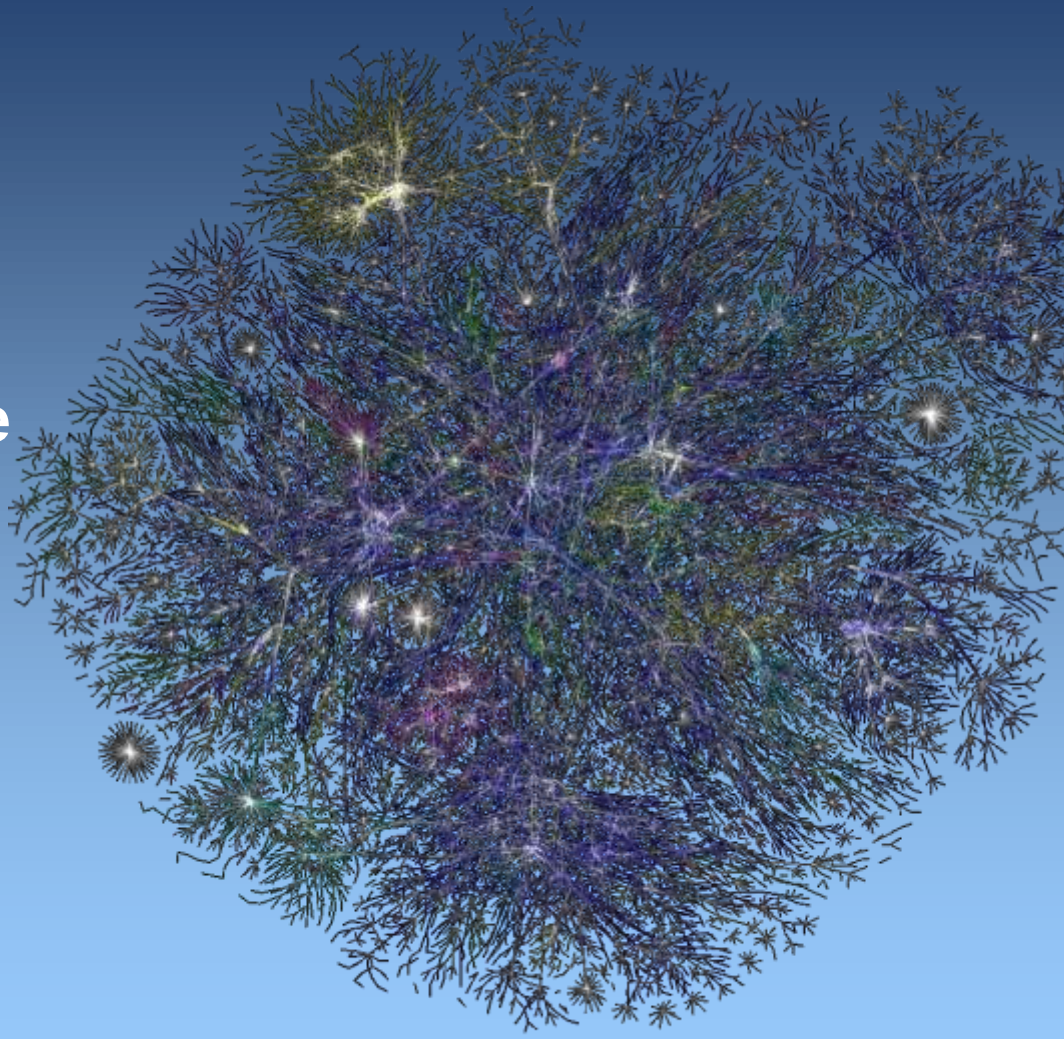
Cloud Computing for National Lidar

- Flexible storage and processing solutions
- Direct access to ALL lidar source data
- Allow for customizable derivative creation from the source data on the fly
- Source data is read only & certified by USGS and partners



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Create customized analysis-ready derivative model solutions on the fly, such as:

- Customized rasters with different resolutions, parameters
- Projection on the fly
- Slope and Aspect Grids
- Flow Direction Grids
- Flow Accumulation Grids
- Synthetic Flow Channels
- Canopy Height Models
- Canopy Density Models
- Height to Live Crown Models
- Intensity images
- Be flexible enough to allow for data innovations and partner ‘plug-in’ models to directly access all the source data

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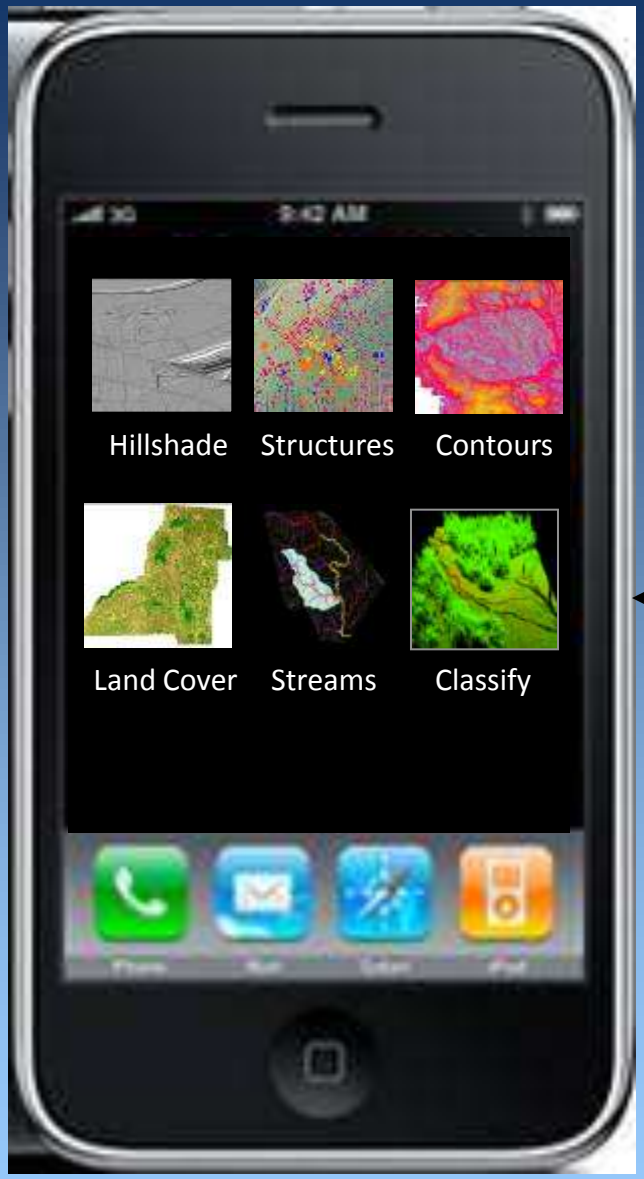
- Want your lidar processed a certain way?
- There's an app for that
- * Corresponding fees may apply
- Based on 'certified' USGS point cloud source data
- Many opportunities to collaborate GEON, NRCS, GOOGLE, ESRI and USGS wide



3rd party Analysis algorithms

National Lidar

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Migration of the NED Source Data

- Resampling higher resolution data and merging it into the lower resolution datasets
- This has been an automatic process as the 10 meter source has been included into the NED replacing the 30 meter source
- The NED 1 and 1/3 datasets are kept in sync having identical source data used to prepare them
- Originally there was a similar assumption for the inclusion of the higher resolution source data

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Importance of improving the NED layers

30 meters Source

10 meters Source

1 meters Source

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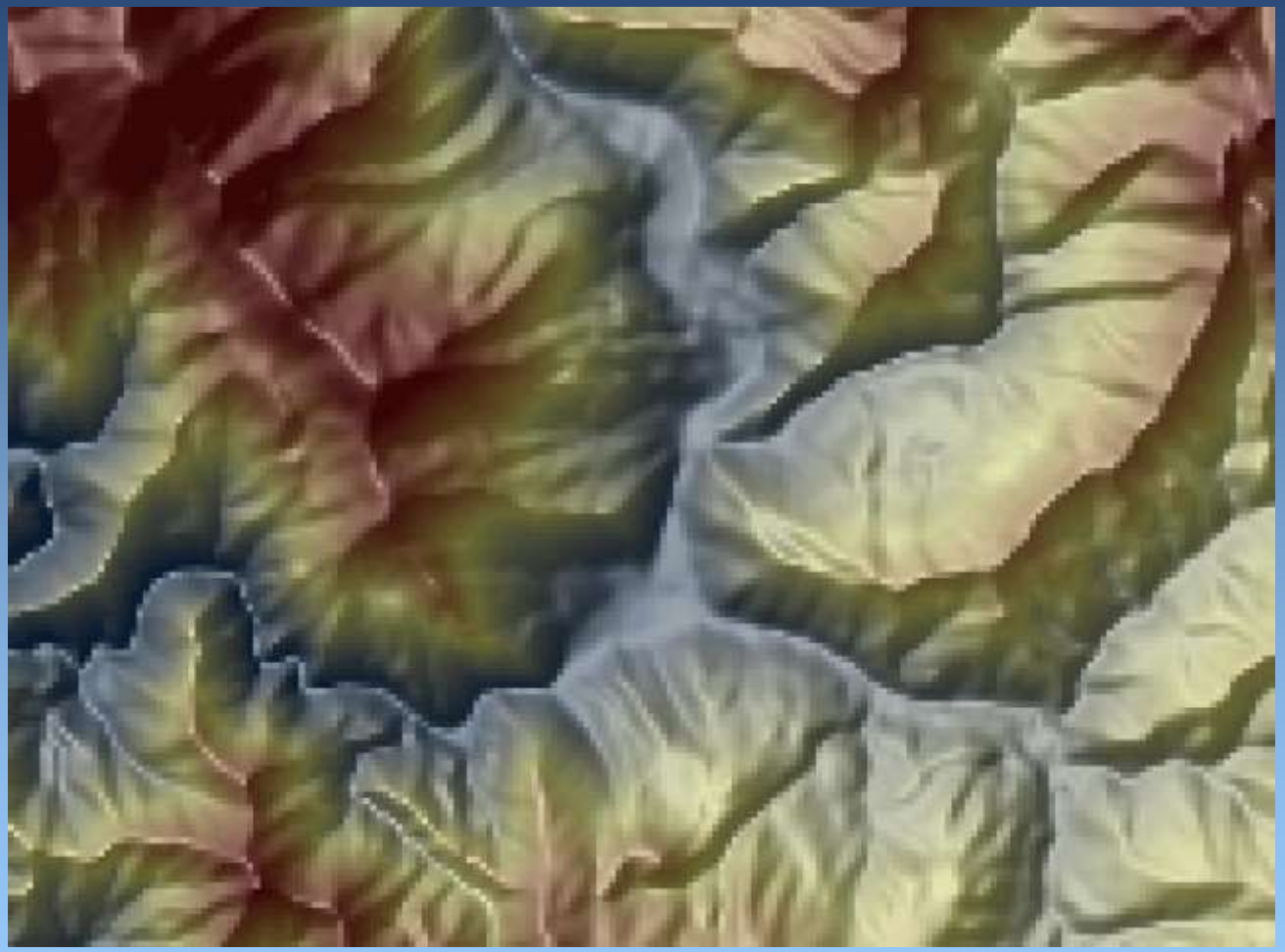
Elevation – 30m, 10m, & 1m



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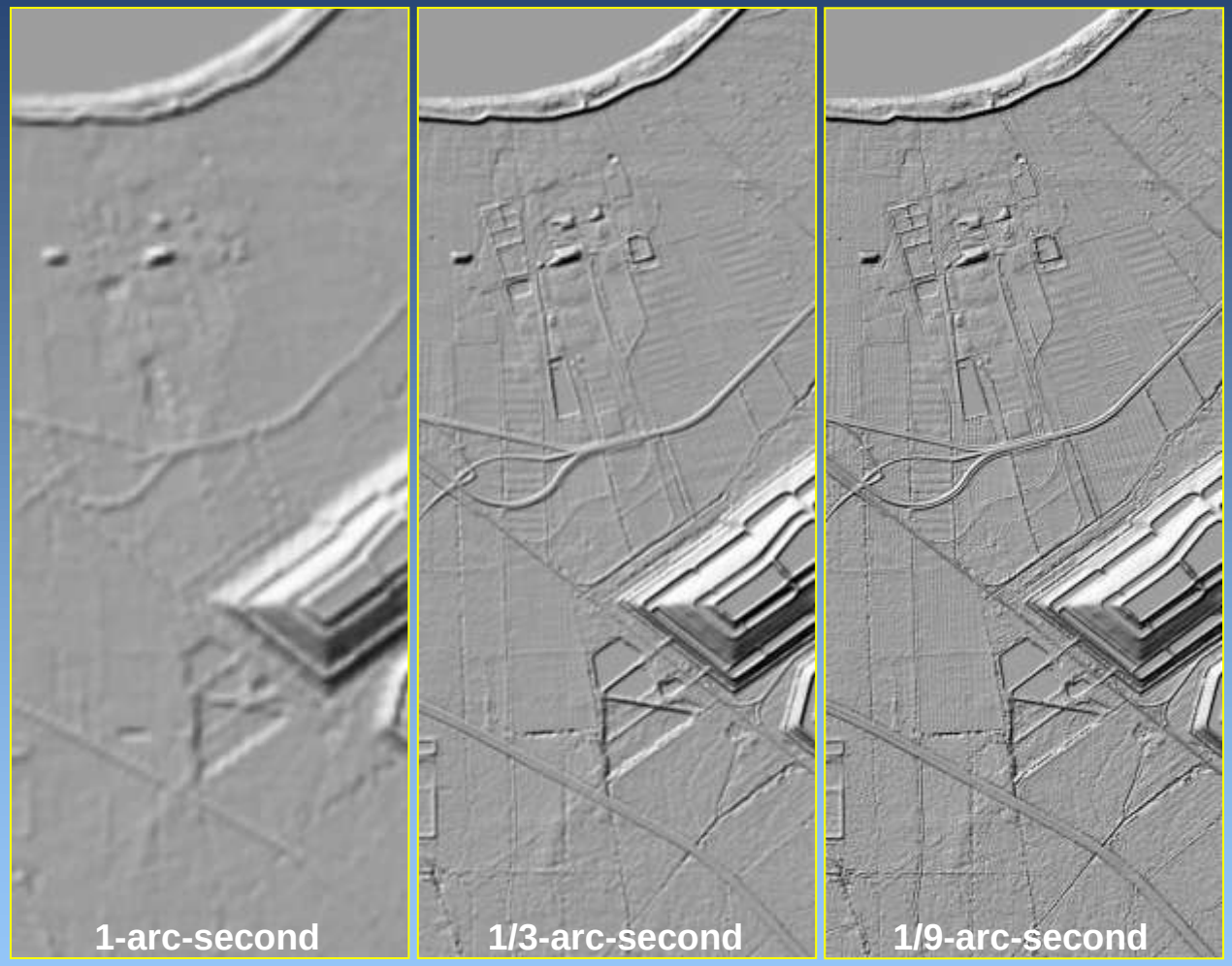
Higher resolution source migration



(30 meters) (10 meters) (3 meters)

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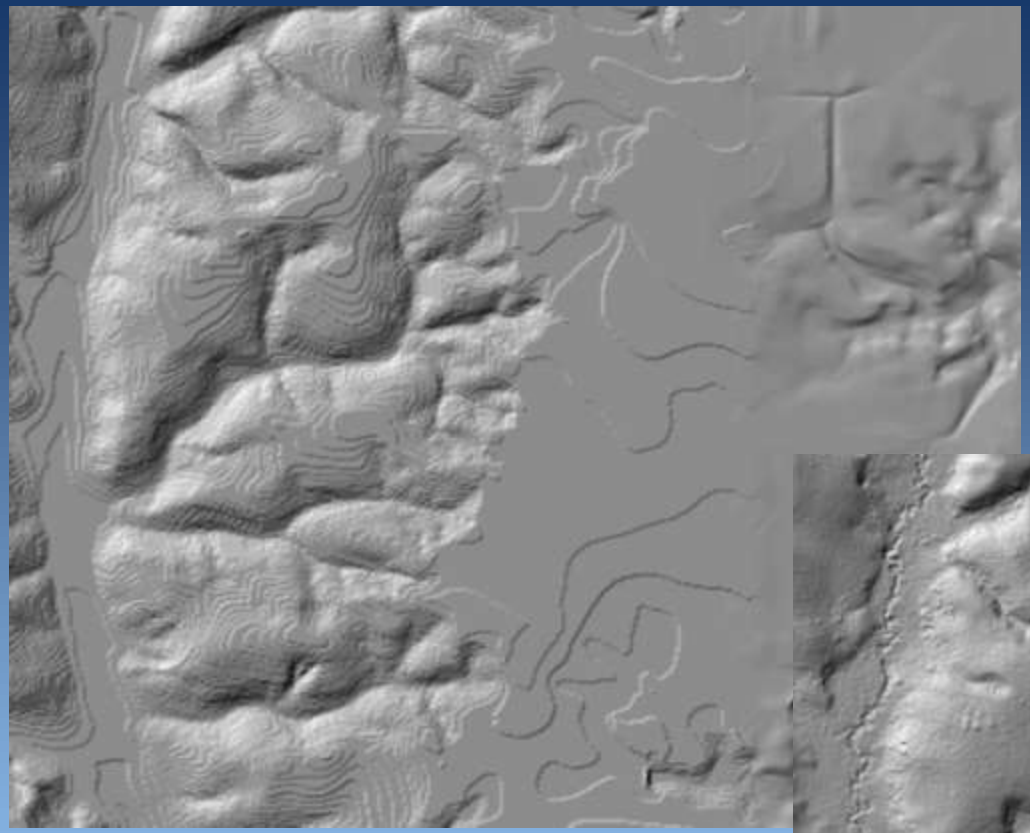
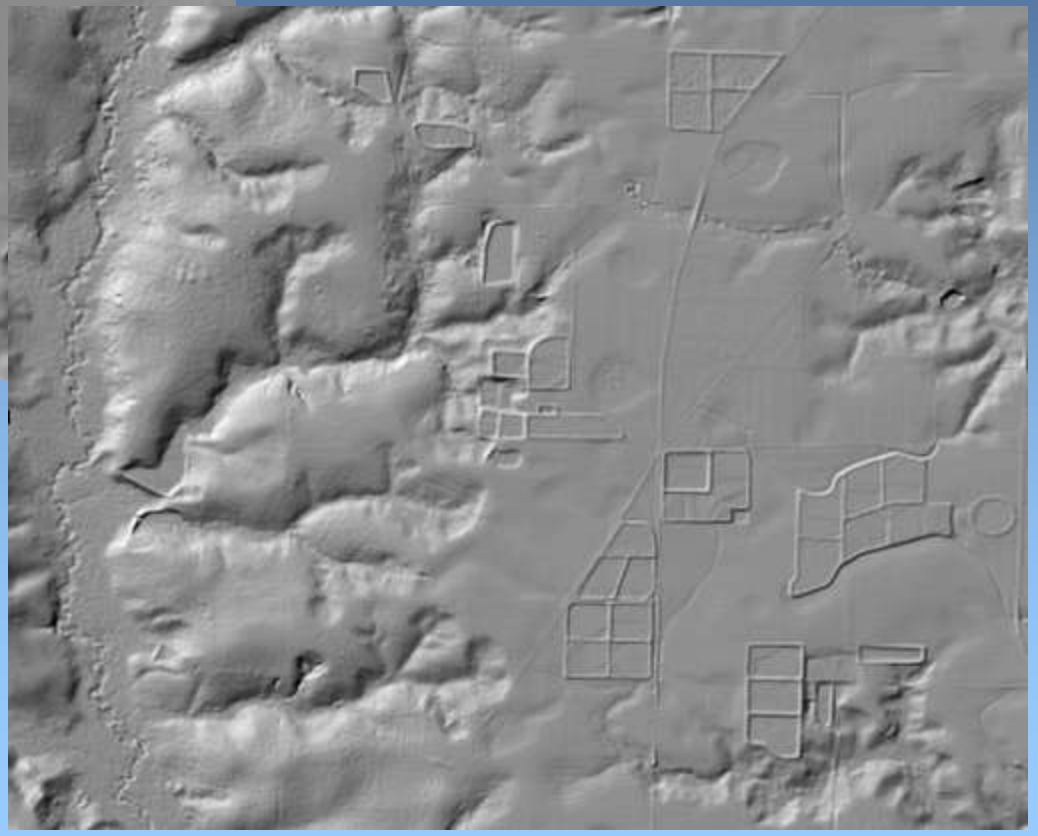


NED 1/3 10M source prior to 3M source migration

Present NED 1/3 with 3M source



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Migration Continued:

- Unfortunately, the consistency of the high resolution datasets has not stabilized
- Many of the high resolution datasets received are very useful for specific applications
- However, the dataset may not meet the NED criteria to which the 1 and 1/3 layers are held to
  - Flattened water bodies
  - Properly bare-earthed surface
  - Good resampling and minimal seam lines
  - Minimal TIN artifacts

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Migration Continued:

- The National Elevation Team through the weekly telecons altered the migration policy
  - Higher resolution source datasets which do not meet the criteria of the NED 1 and 1/3 layers but support the NED 1/9 resolution and are the best available for that resolution will be accepted into the NED 1/9 layer
  - Datasets not meeting the criteria the of NED 1 and 1/3 layers will not be migrated
  - Reasons for migration rejection of a dataset and example graphics of the issues are captured for future reference
  - New spatial metadata fields have been developed to support this change

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The Traditional Topographic DEM

- Before lidar, DEMs were most recently created through stereo photogrammetry.
- In this method, 3D breaklines were generated along the banks of water bodies.
- The resulting DEMs therefore had “flat” water bodies.

- Bridges (raised spans) were not included in the DEMs because they are not the ground.
- Road fills over culverts WERE included in the DEM because they are on the ground.
- Depresssions (sinks) were mapped, like everything else.

- This is a traditional TOPOGRAPHIC DEM

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Lidar DEMs

- Lidar does not inherently include breaklines
- Water bodies have uneven TIN'd surfaces
- Stream channels may contain elevation irregularities
- Bridges are usually removed during processing

- This is also a topographic DEM, though not of the same *character* of a photogrammetrically-derived DEM

- NED customers have expressed dissatisfaction with the appearance of lidar-only DEM surfaces.

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Hydro-Flattened DEMs

- Hydro-flattening modifies lidar-only DEMs to resemble traditional photogrammetric DEMs
  - Water bodies are flat
  - Wide streams and rivers are flat bank-to-bank and follow downhill gradient
  - Bridge spans are removed
  - Road fills over culverts remain

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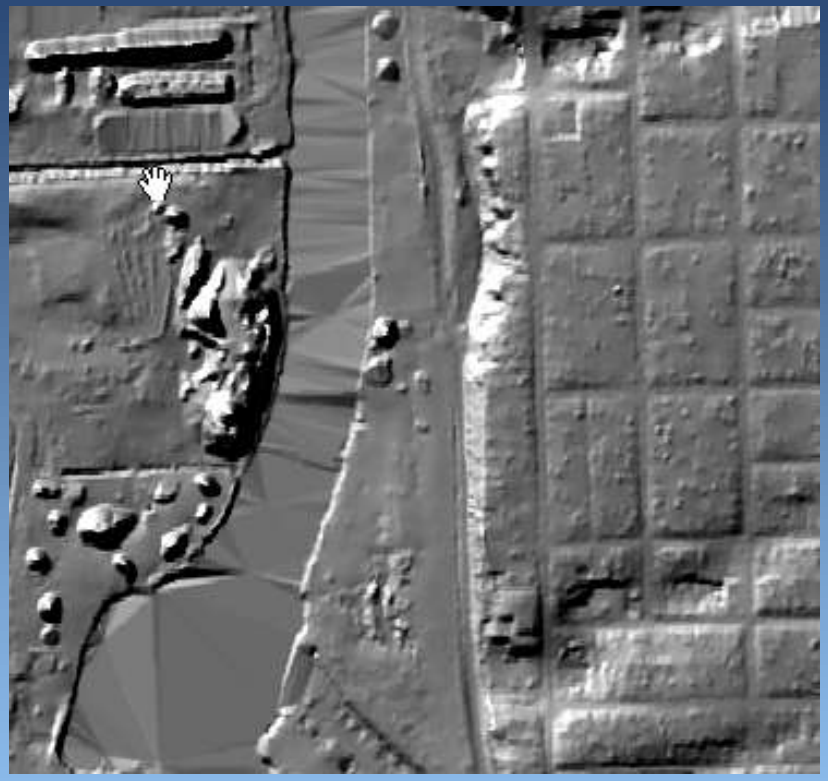
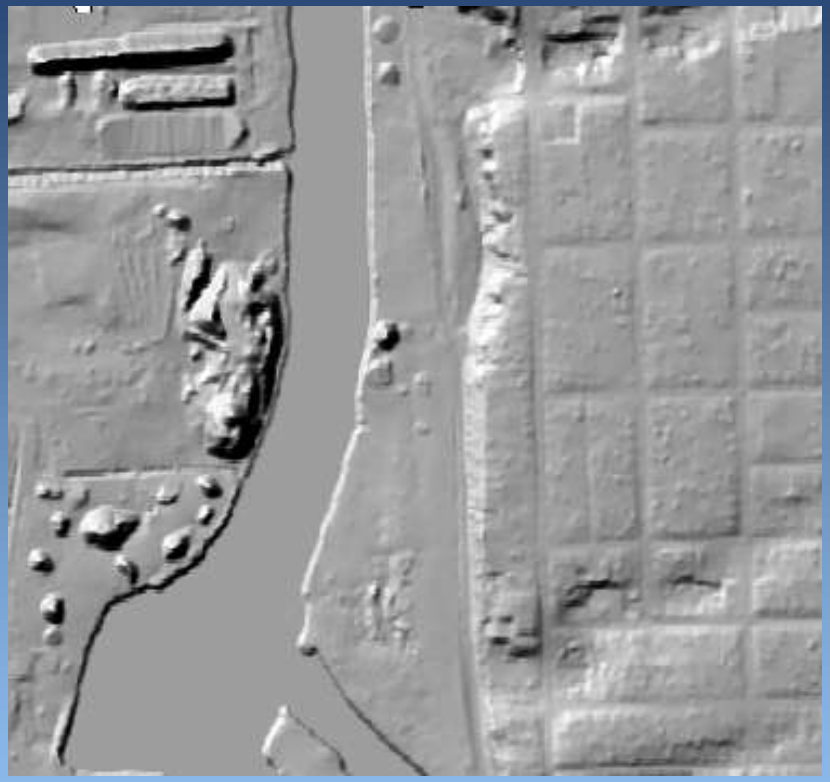
Hydro-Flattening Examples



Lidar only



Hydro-flattened Lidar

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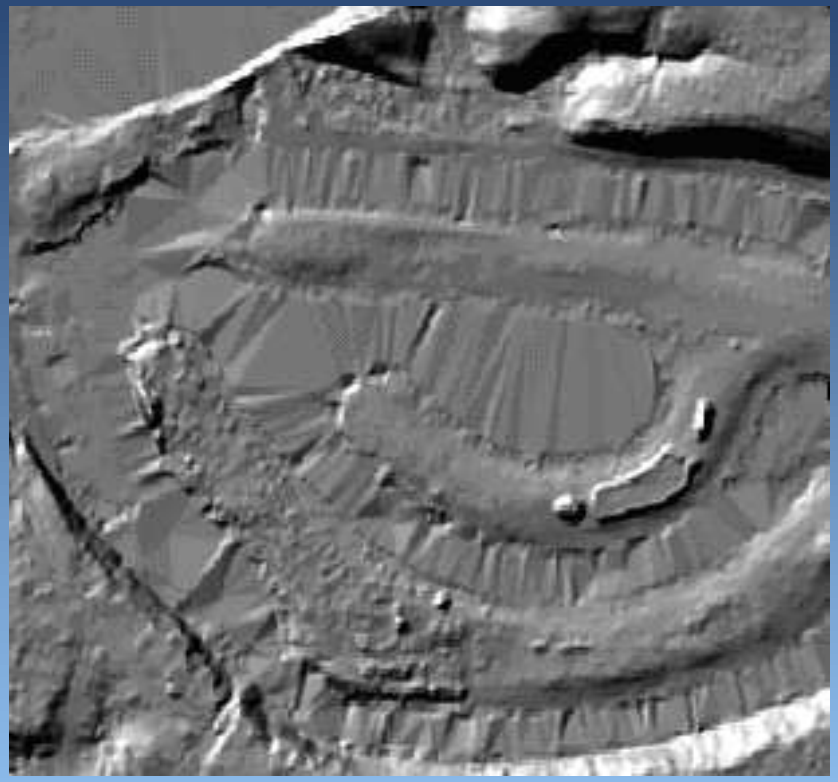
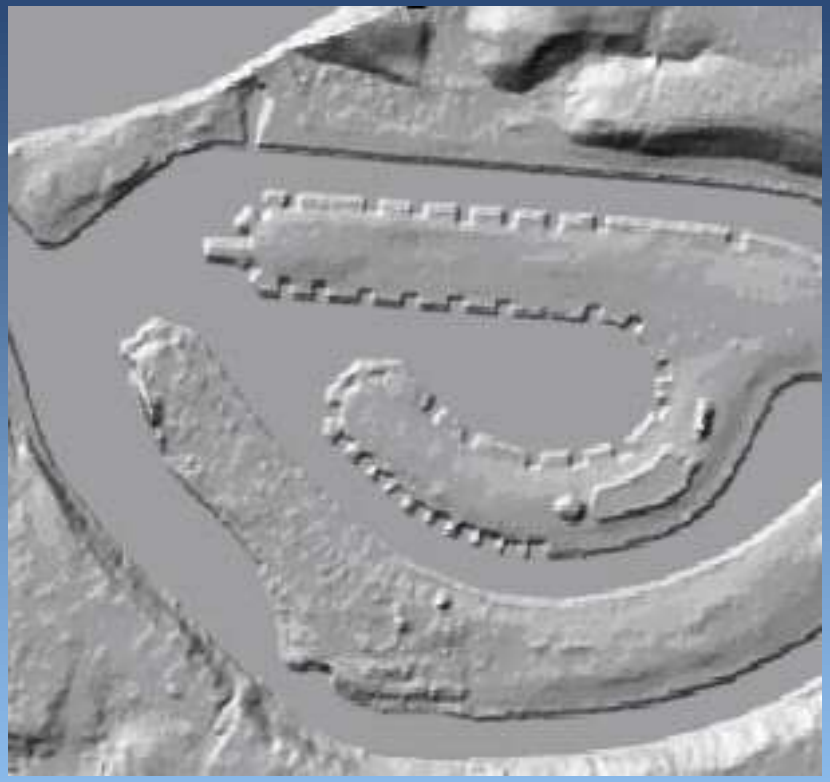
Hydro-Flattening Examples



Lidar only



Hydro-flattened Lidar

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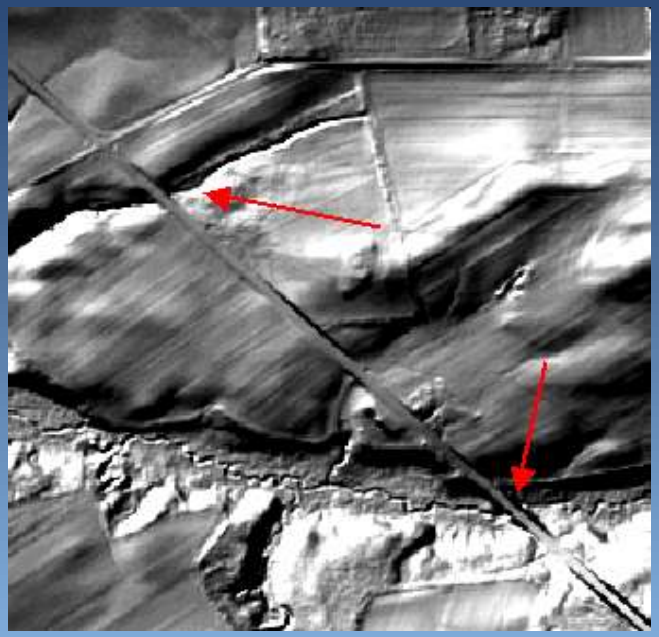
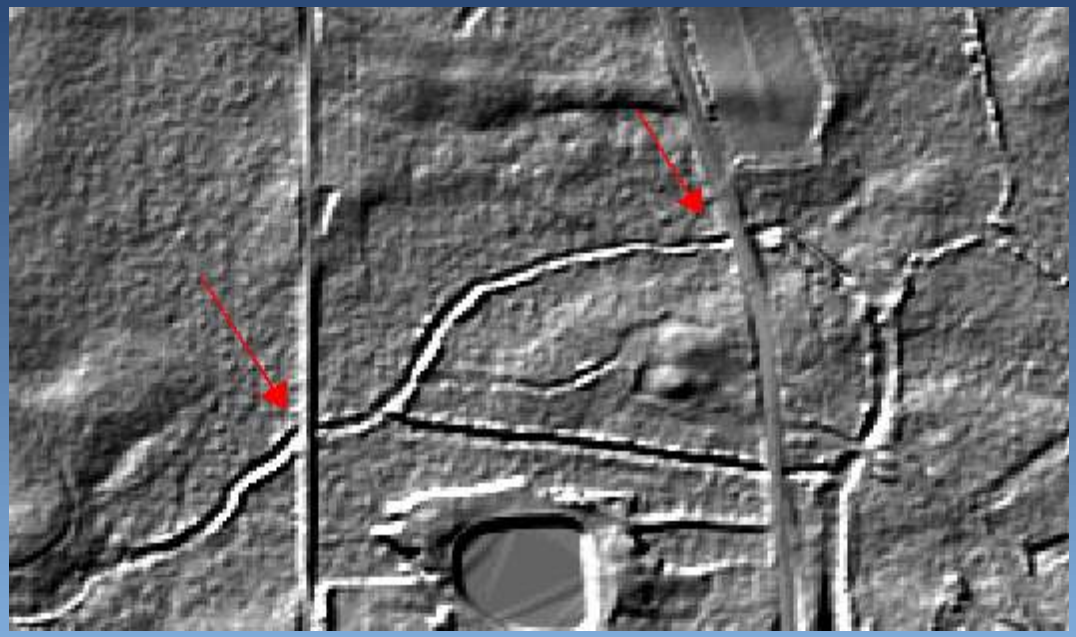
Hydro-Flattened Examples





These examples show topographic handing of the road fills over culverts. This DEM is NOT hydro-enforced.

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Hydro-Enforced DEMs

- In 2001 for the NC Floodplain Mapping Project, Watershed Concepts had their lidar subcontractor EarthData, develop “breaklines” (preferred term is “hydro-lines”) to support their modelling efforts

- The hydro-lines flattened water bodies, imposed smooth gradients on wider rivers, and forced streams to flow downhill.

- Hydro-lines for **culverts** were uniquely attributed so they could be included or excluded during DEM development.
  - If excluded, the resulting surface was a TOPOGRAPHIC DEM
  - If included, the resulting surface was a **HYDROLOGIC DEM**

- Most current hydro-enforced DEMs do not distinguish culvert segments from open channels
  - **→ Ground elevations are removed above culverts to allow the surface to reflect continuous water flow.**

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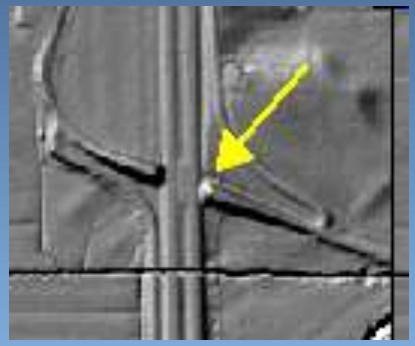
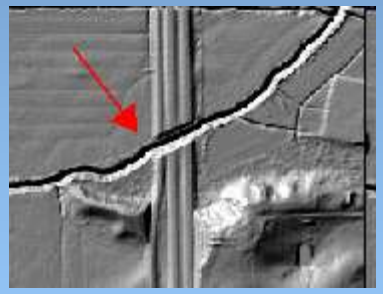
Hydro-Enforced Examples

Culvert cut open through the highway



Bridge Overpass properly removed



Culvert cut open through the highway

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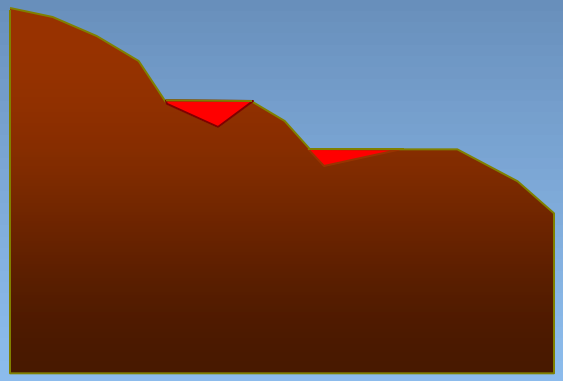
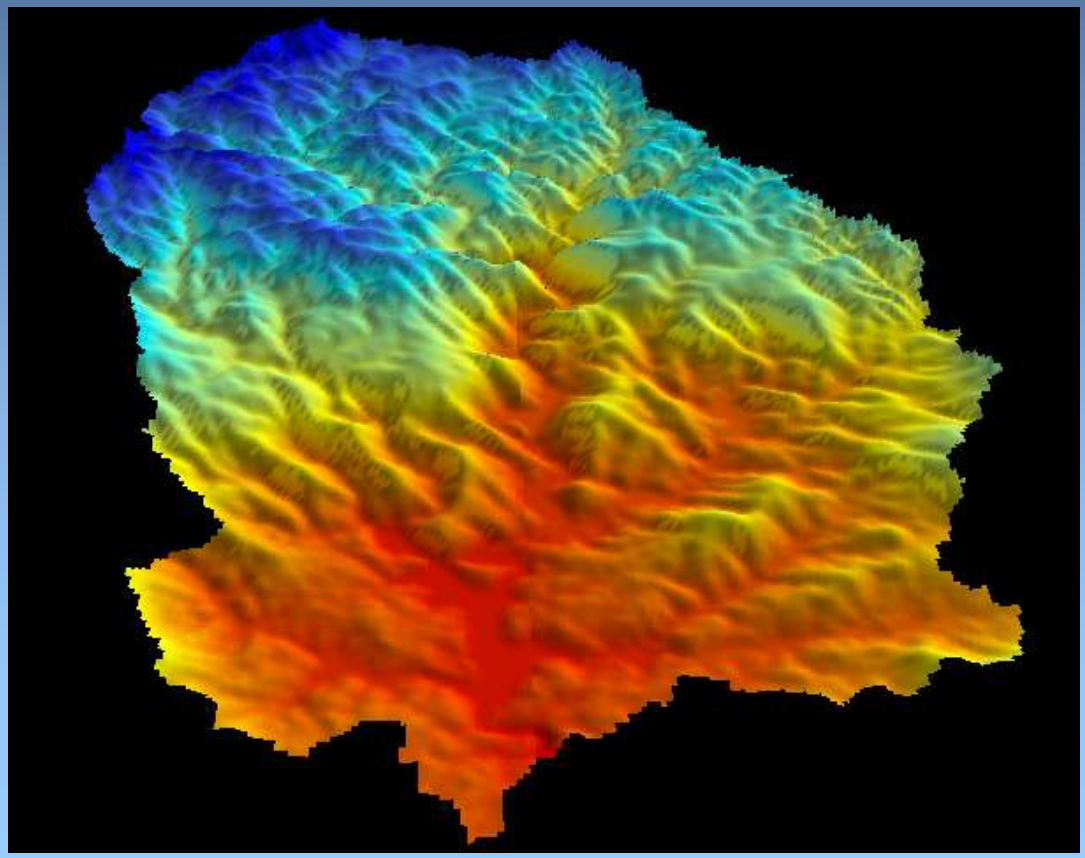
Hydro-Conditioning

- Hydro-conditioned DEMs are an extension of hydro-enforced DEMs
- In addition to representing water flow across the surface, they also have depressions (“sinks”) filled to the natural outlet elevation
- These are also HYDROLOGIC DEMs





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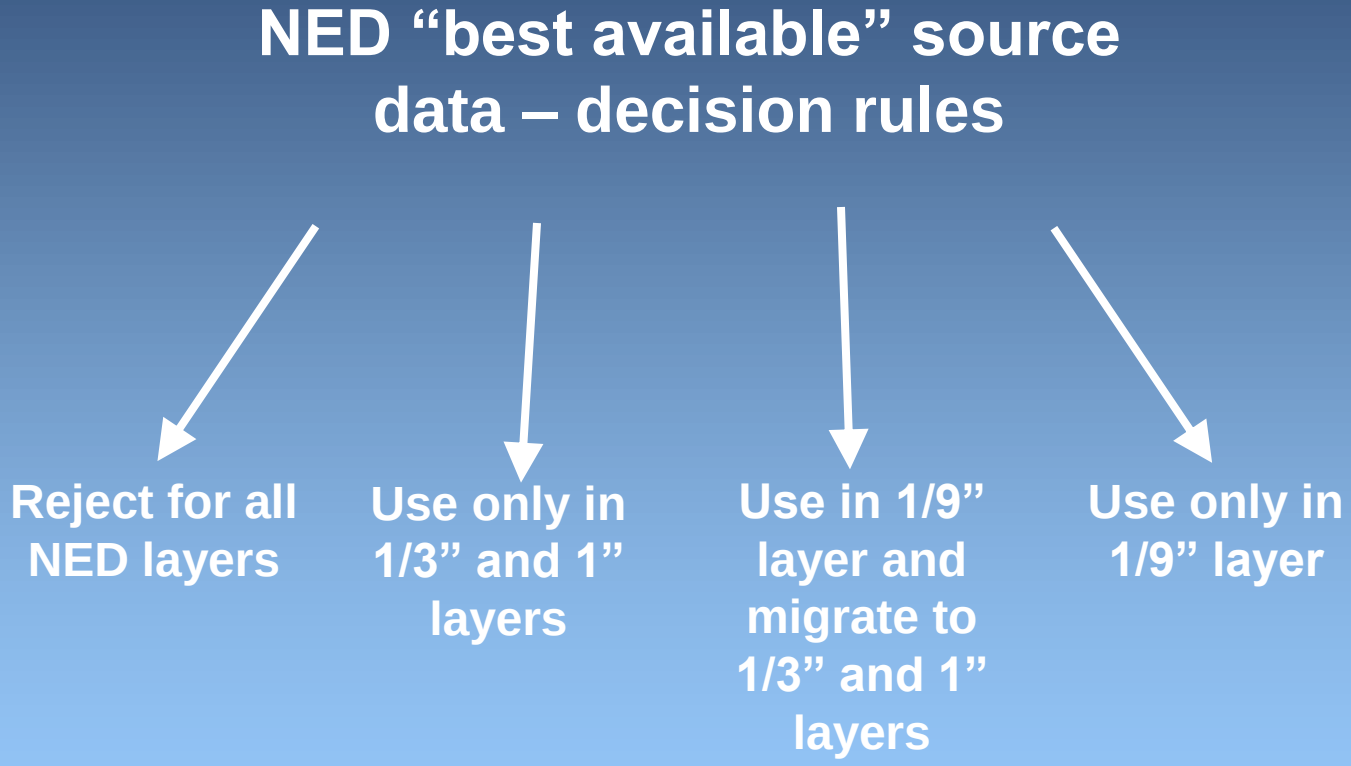
“Best Available”



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Criteria for determining “best available” data for use as NED source data

- Reject from all NED layers
  - Water bodies higher than adjacent ground
  - Large number of data voids
  - Severe mismatches along tile edges
  - Poor bare earth processing (lots of residual vegetation and/or buildings)
  - Improper handling of overpasses
  - Excessive tinning
  - A cumulative effect caused by the above issues
  - No vendor metadata

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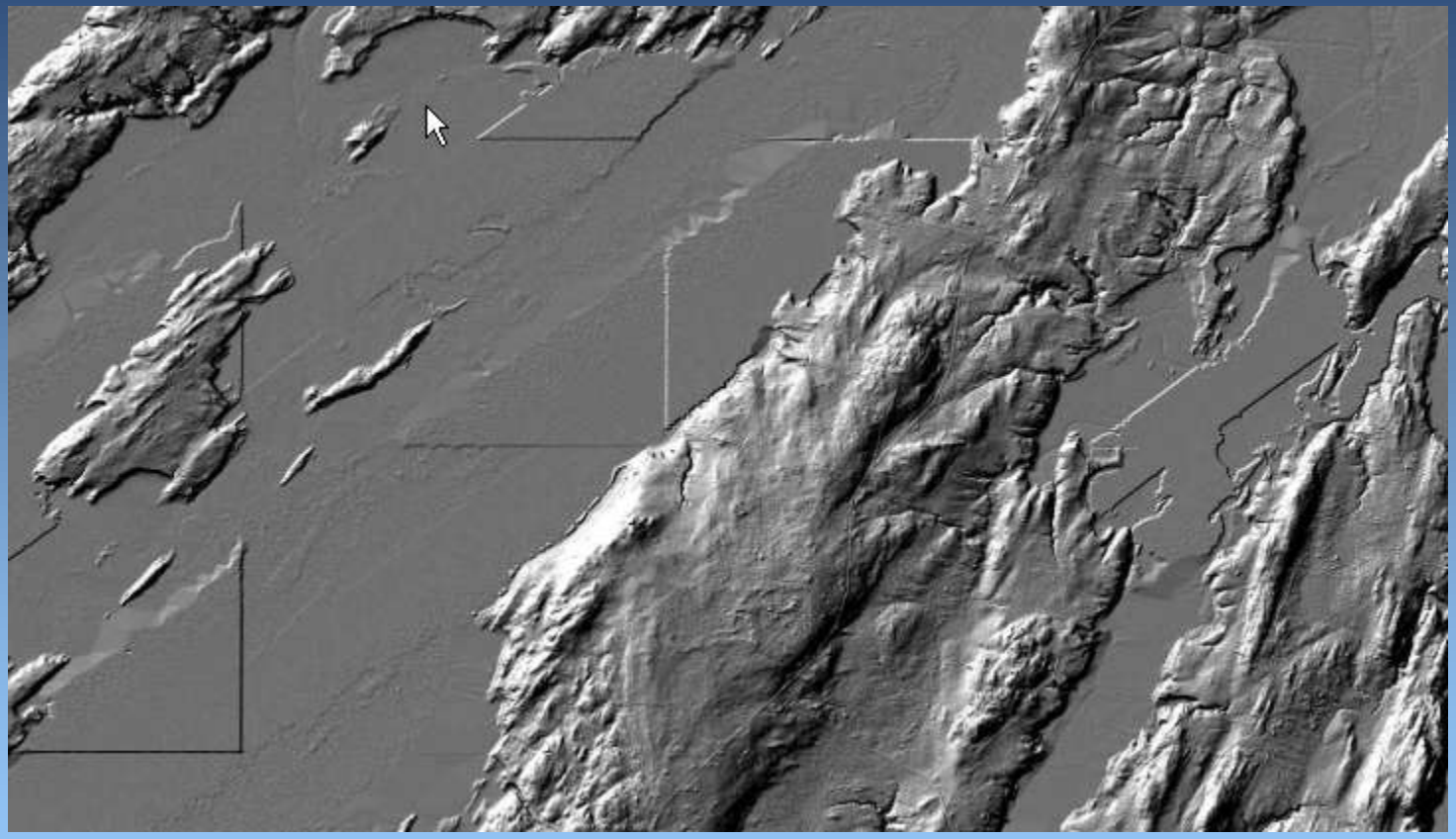
Water bodies higher than land



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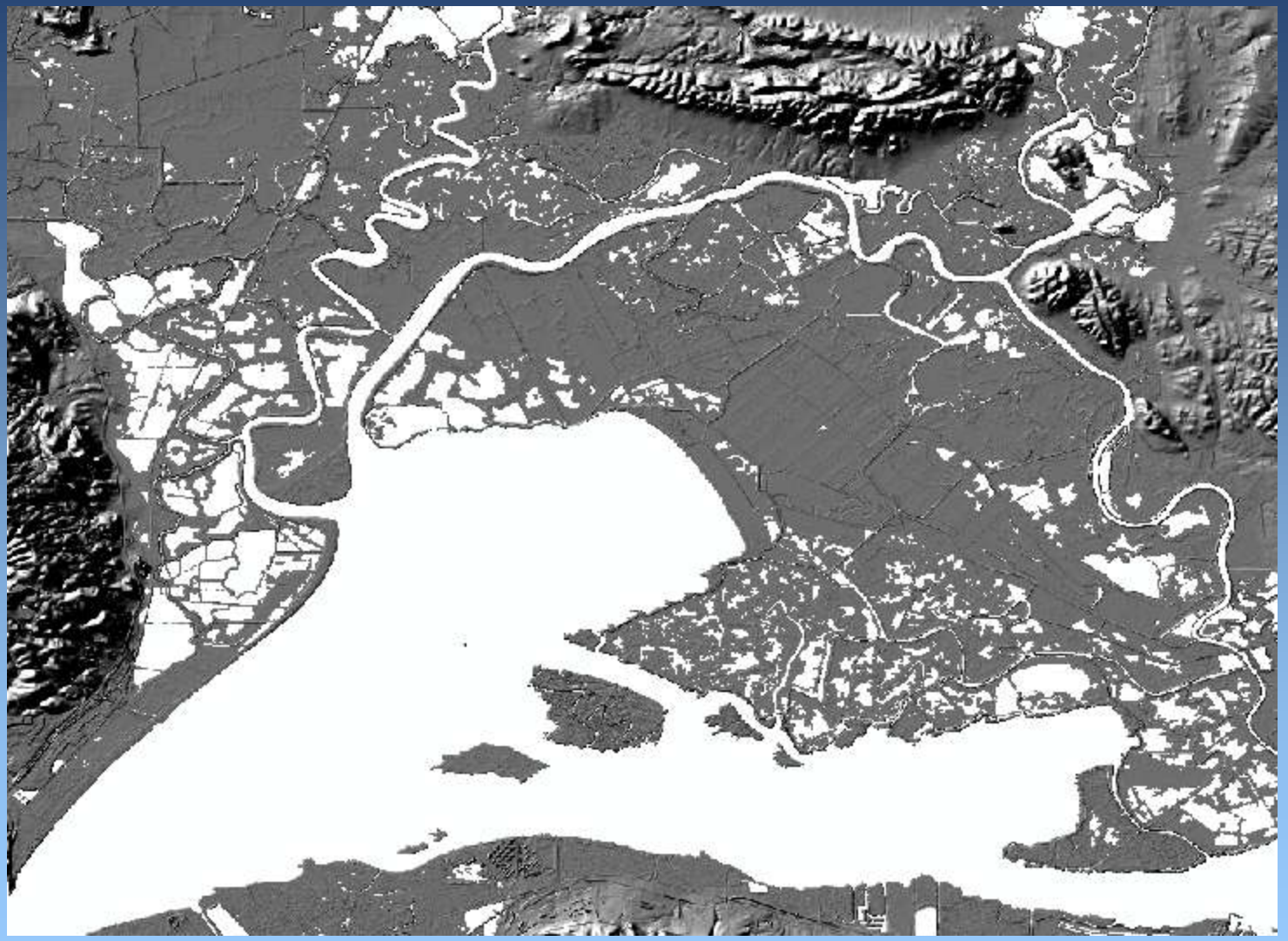
Large number of data voids



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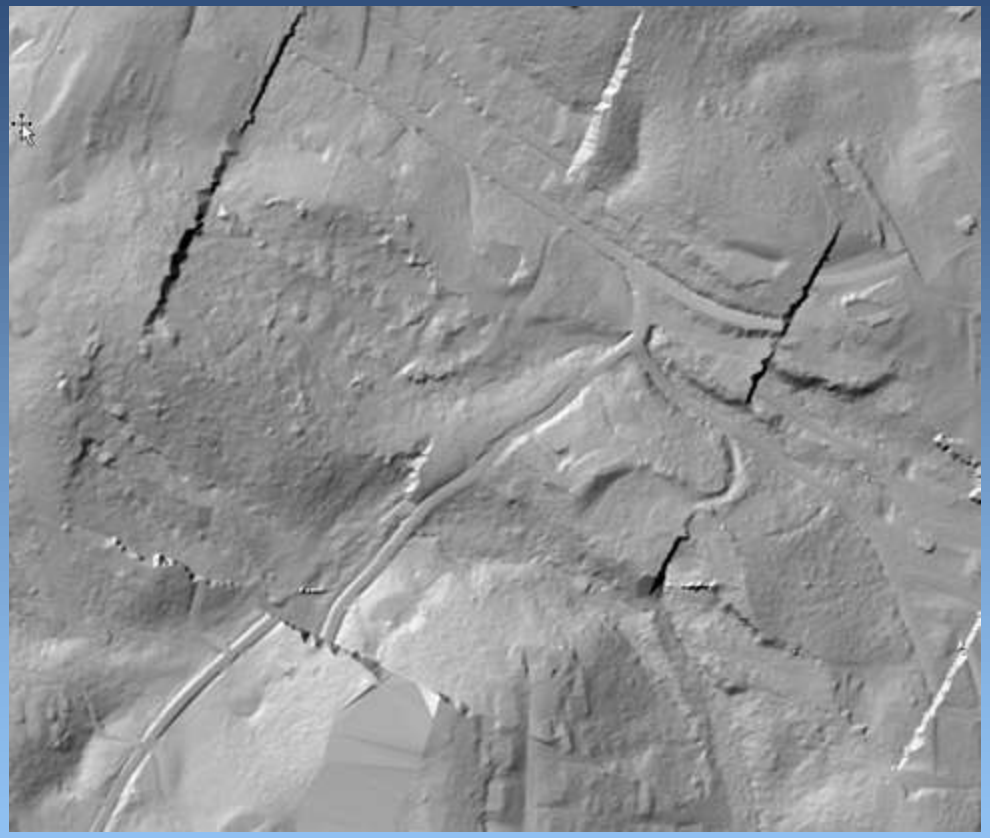
Misalignment of data



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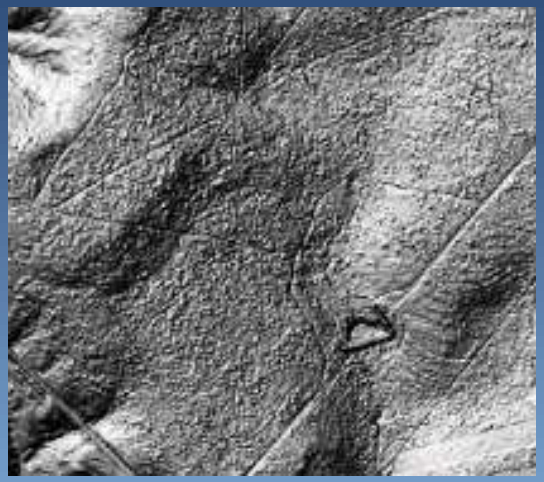
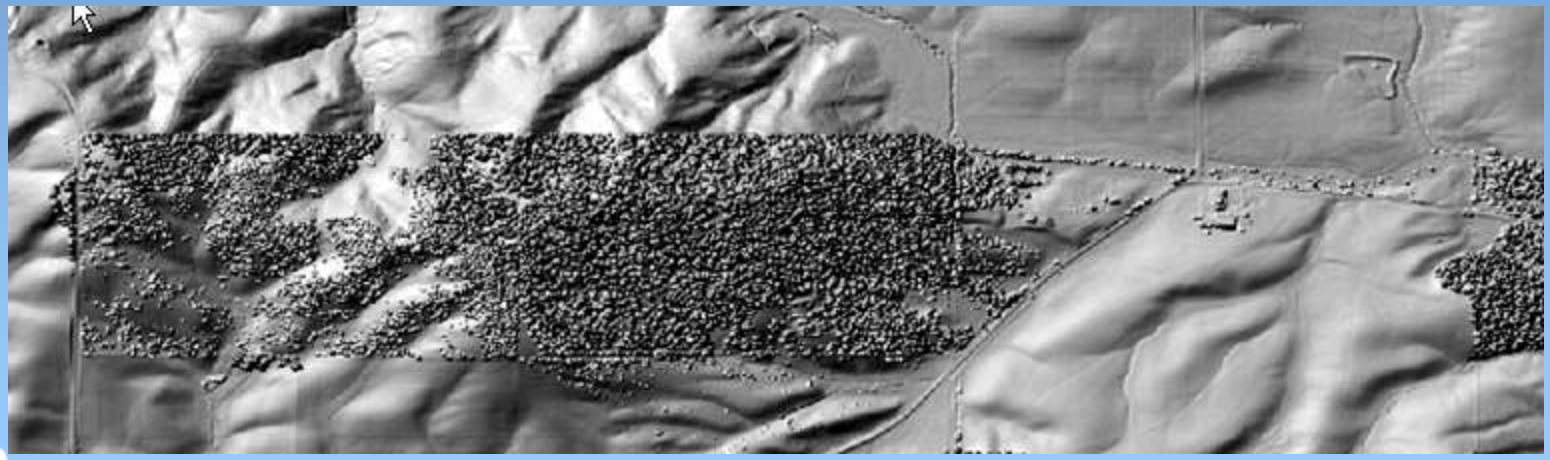
Poor bare earth process





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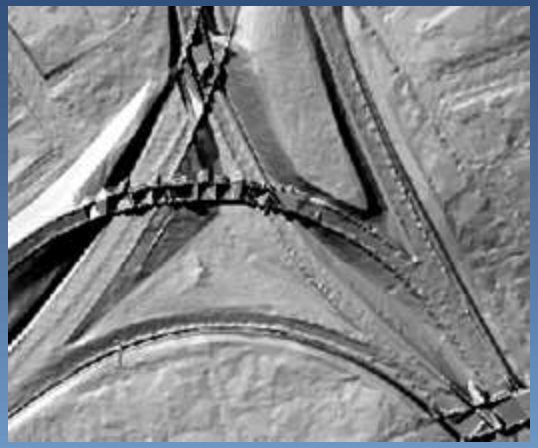
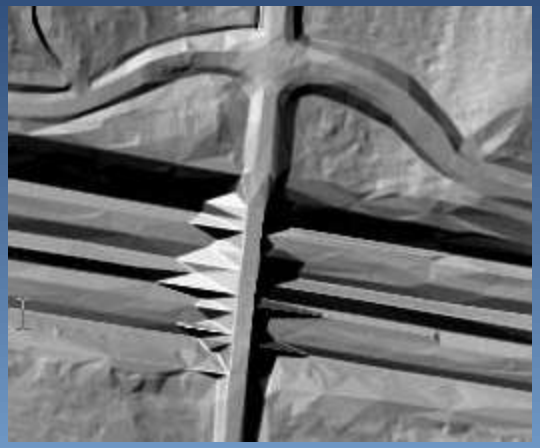
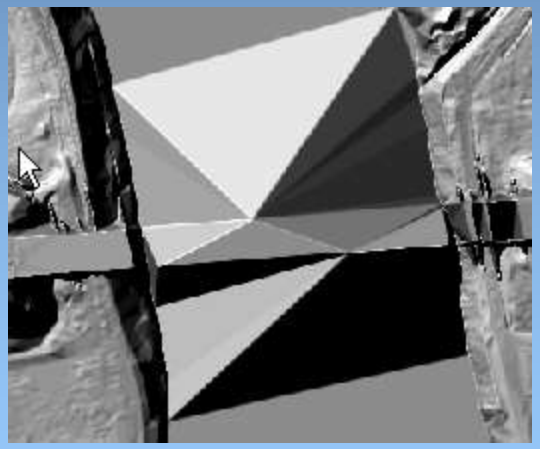
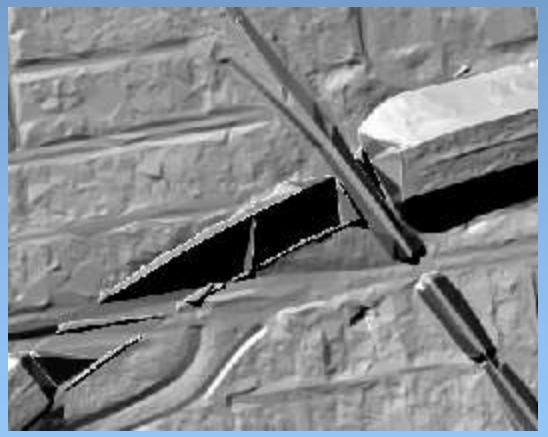
Improper handling of overpasses





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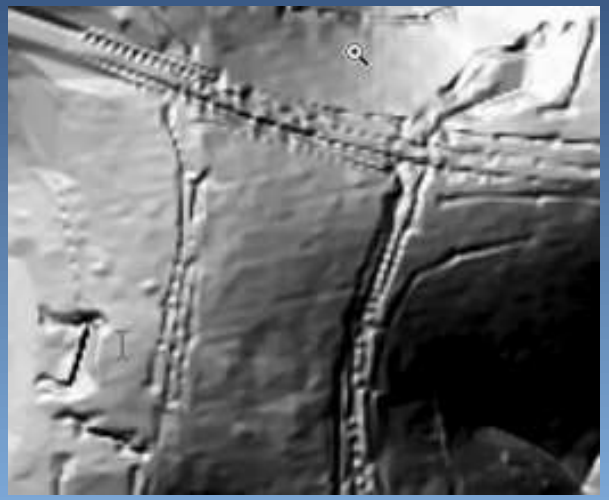
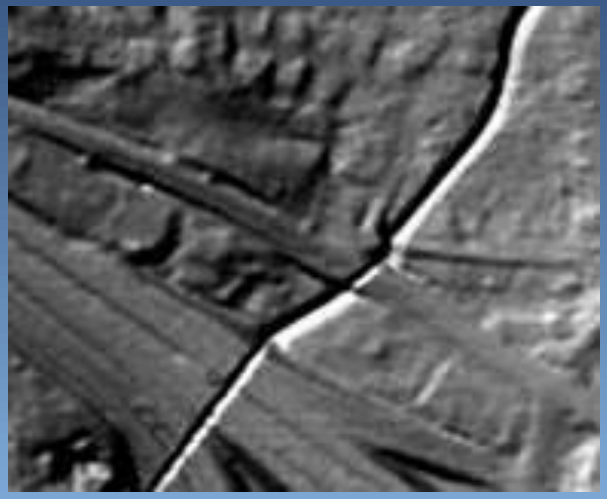
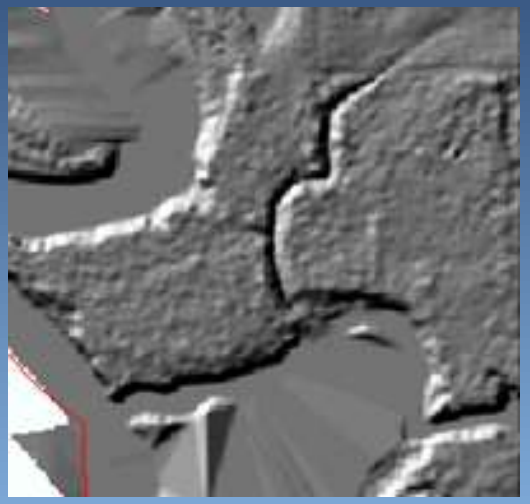
Improper hydro handling

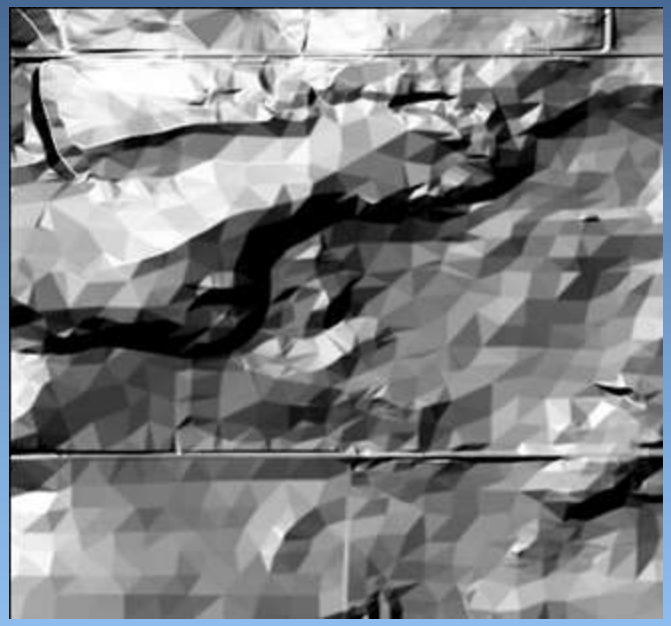




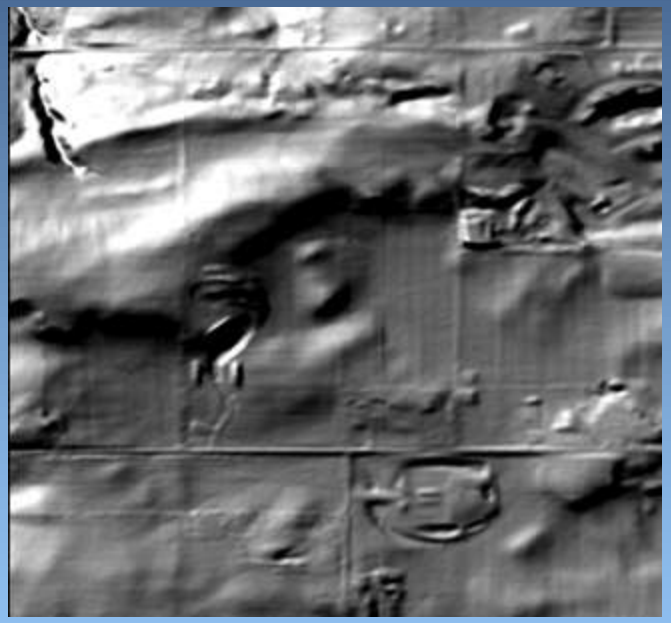


USGS

Excessive tinning



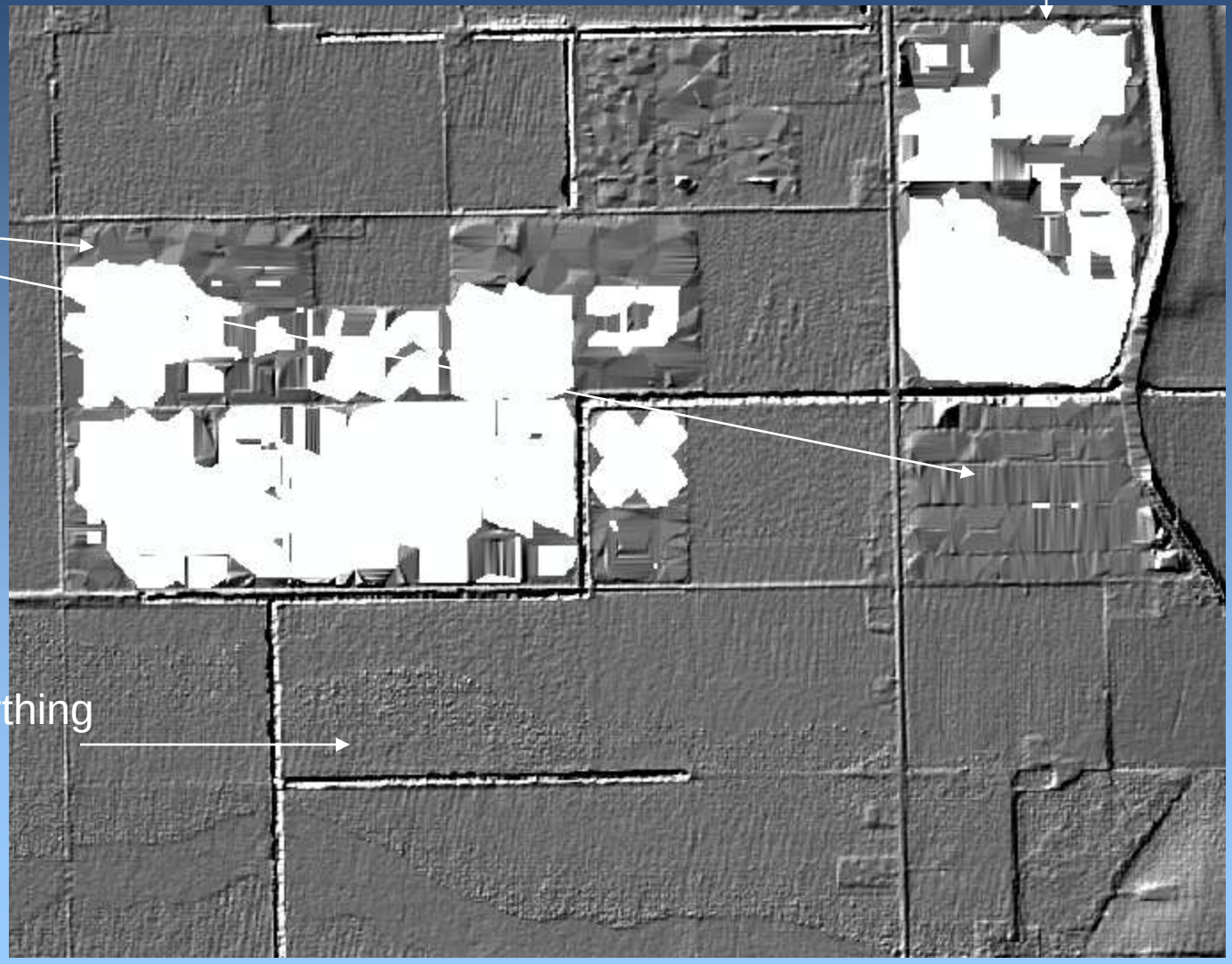
Excessive Tinning



Expected surface

USGS

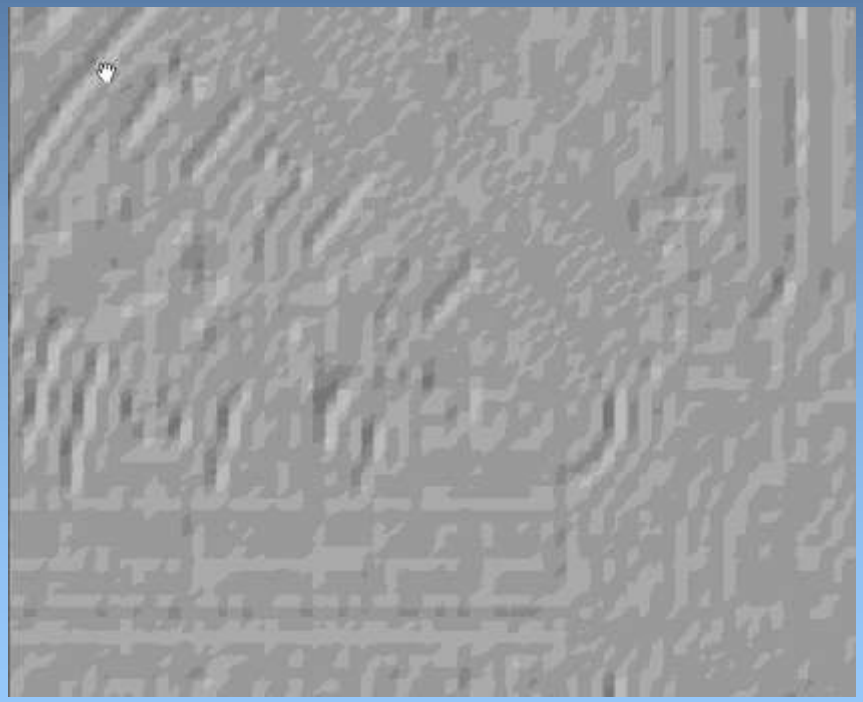
Cumulative effect



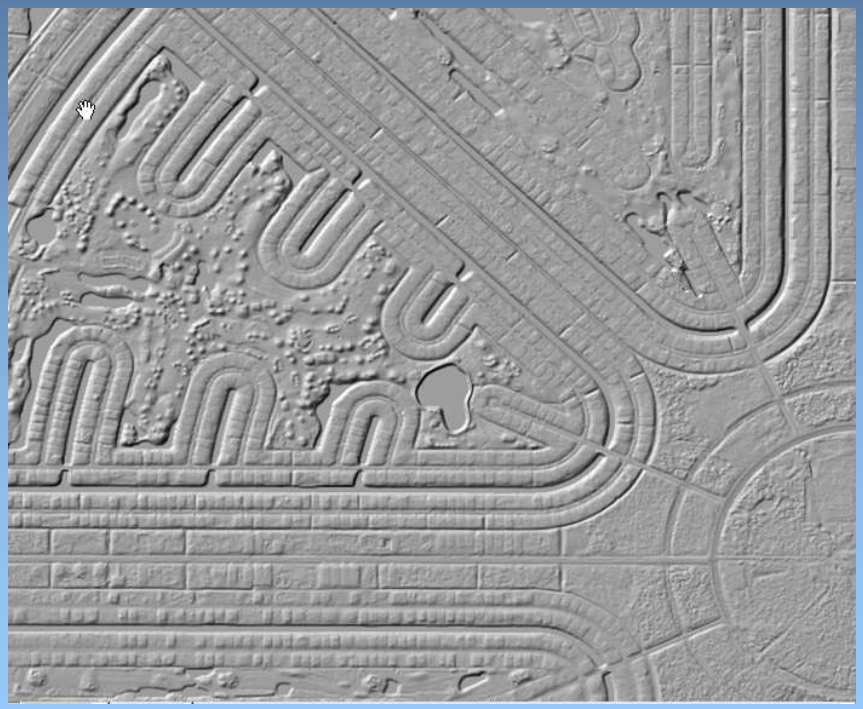
USGS

“Best Available” Criteria Continued:

- Use only in 1-and 1/3-arc-second layers
  - Nominal resolution is coarser than approximately 5 meters



Not acceptable



Expected

“Best Available” Criteria Continued:

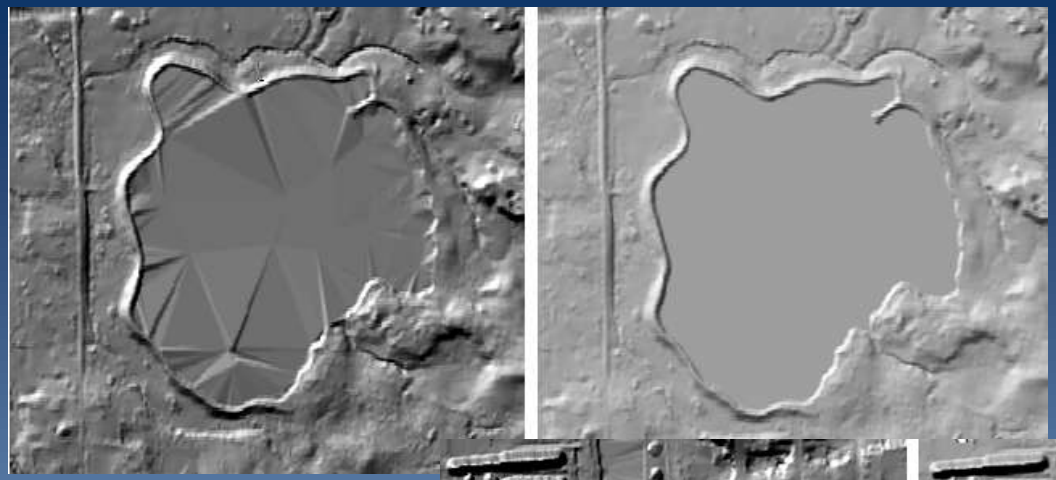
- Use in 1/9-arc-second, and migrated to 1- and 1/3-arc-second layers
  - Water bodies flattened
  - Very minimal TIN artifacts
  - Very minimal residual vegetation and/or buildings in bare earth grids
  - Replaces very poor source data (i.e., the worst MP or GPM quads)
  - Vender Metadata is available

USGS

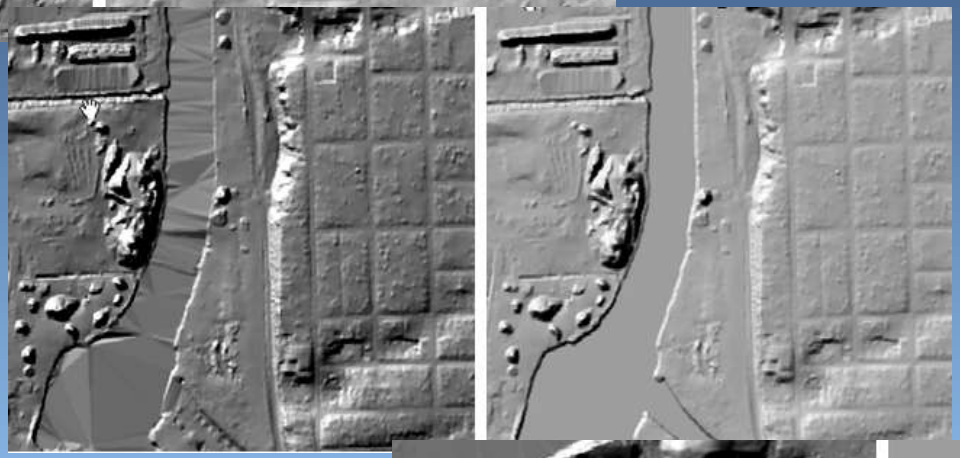
“Best Available” Criteria Continued:

- Use only in NED 1/9-arc-second layer:
  - Water bodies not flattened
  - Large number of data voids
  - Moderate tinning and artifacts
  - Some residual vegetation and/or buildings in bare earth grids
  - Poor resampling and seam lines
  - A cumulative effect caused by one or more of the above issues

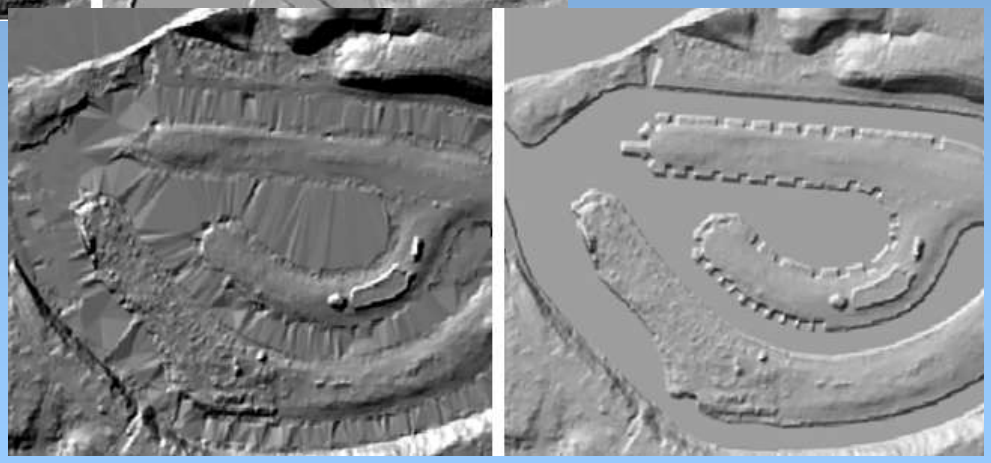
USGS



Flattened water

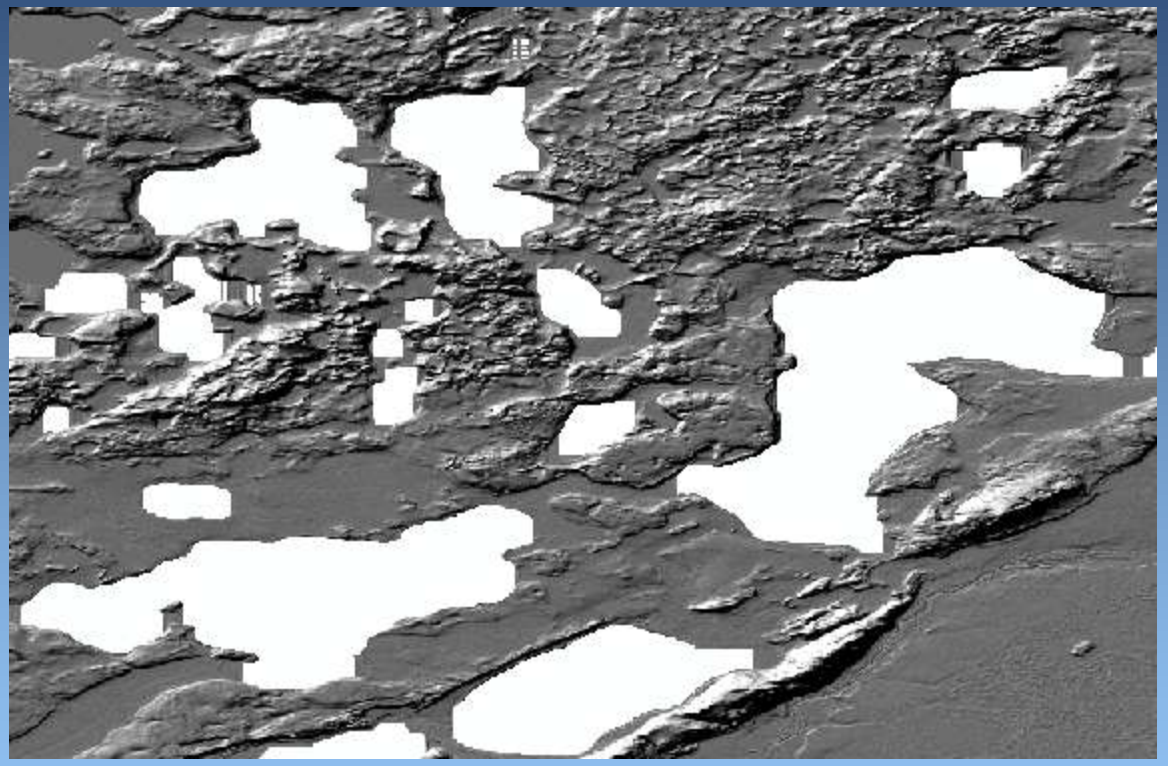


Unflattened water



USGS

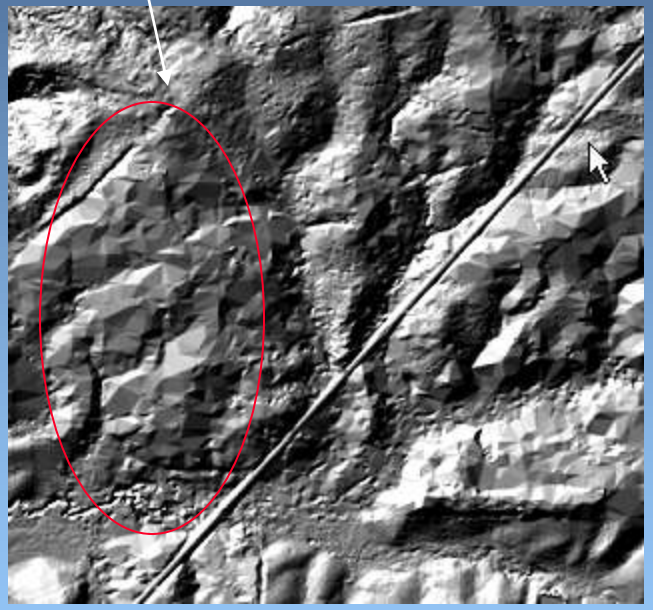
Large number of data voids

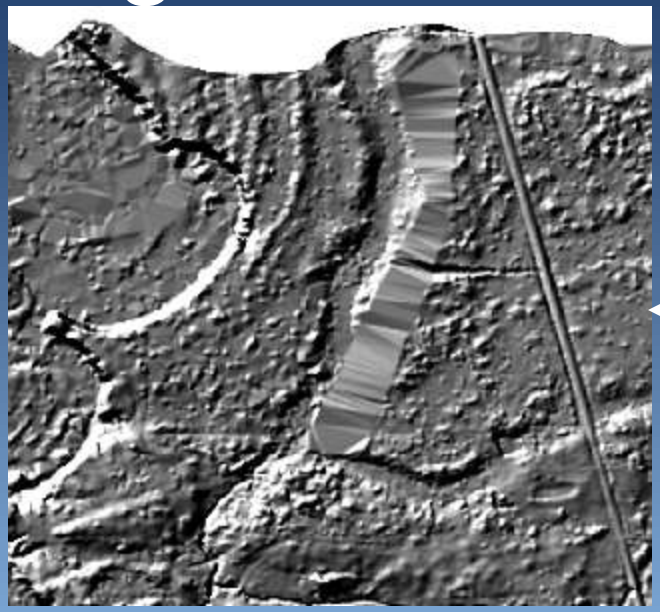


USGS

Moderate tinning and artifacts

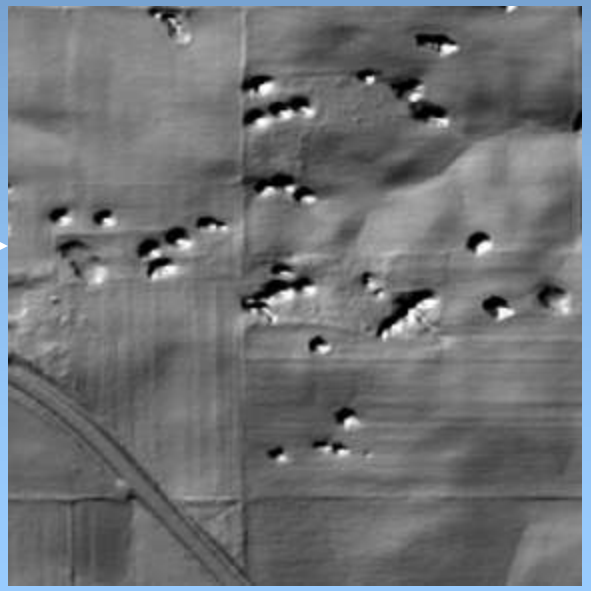
Tinning





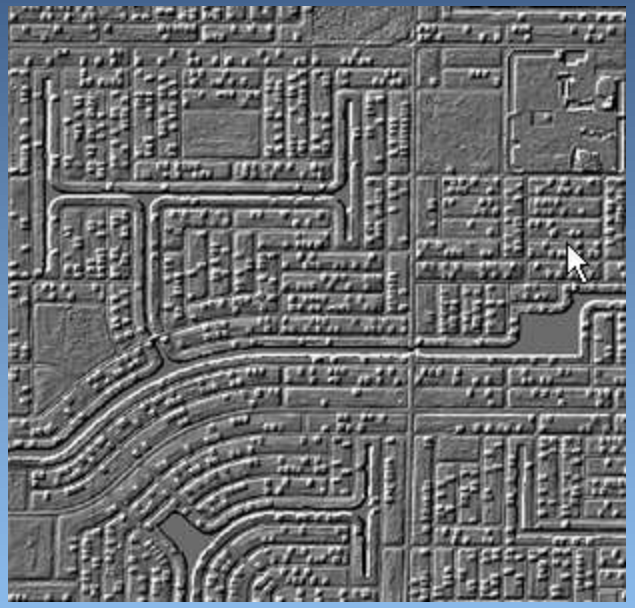
Rough surface and unexplained tin artifact

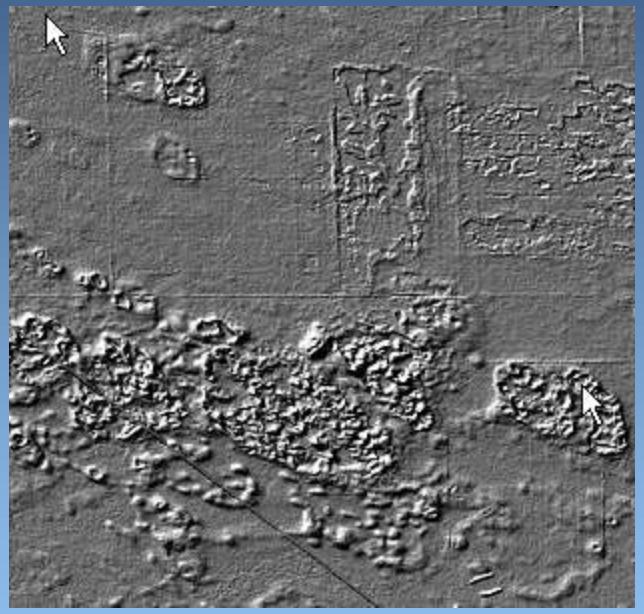
Depressions caused by tree shadows



USGS

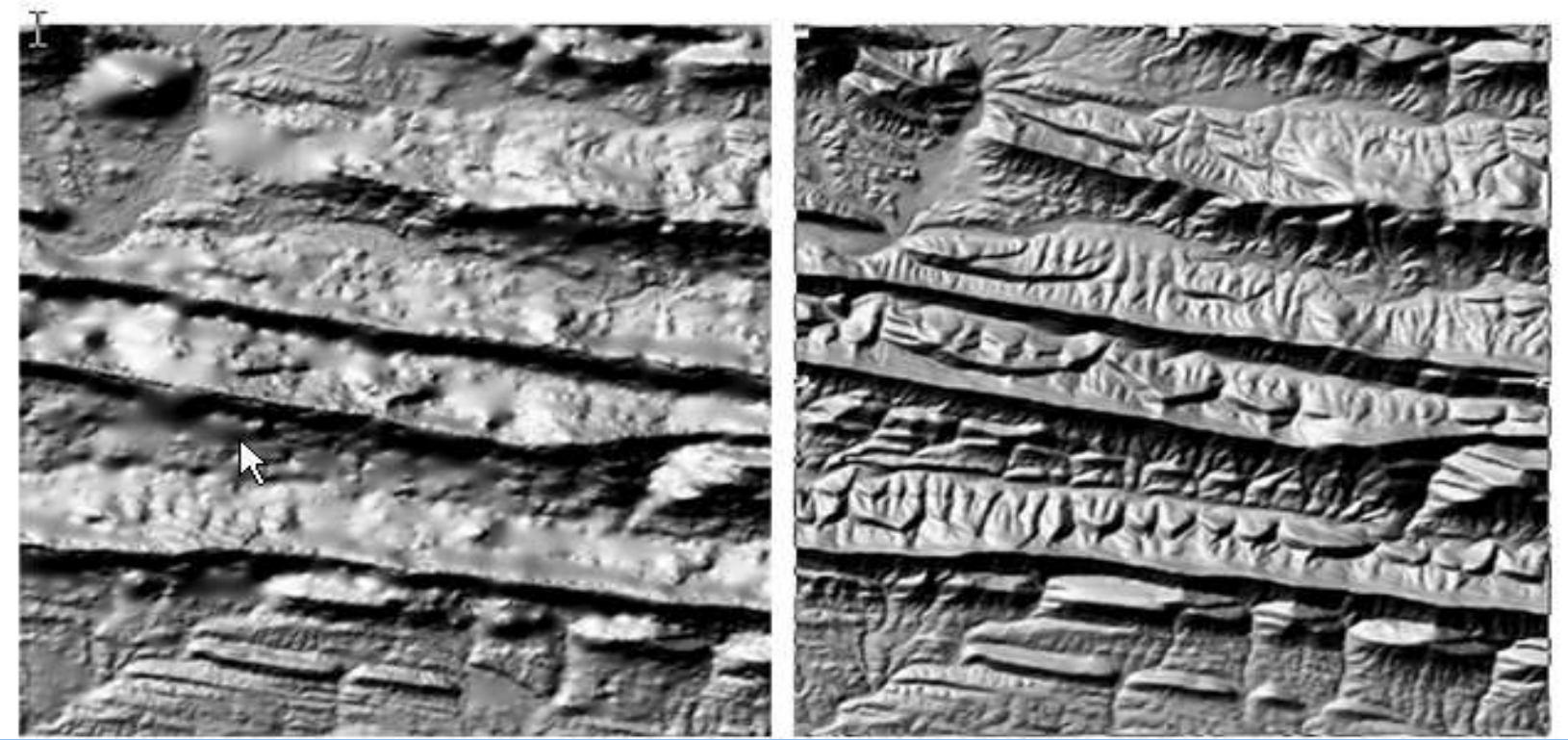
Residual buildings and vegetation





USGS

Arkansas Data Review

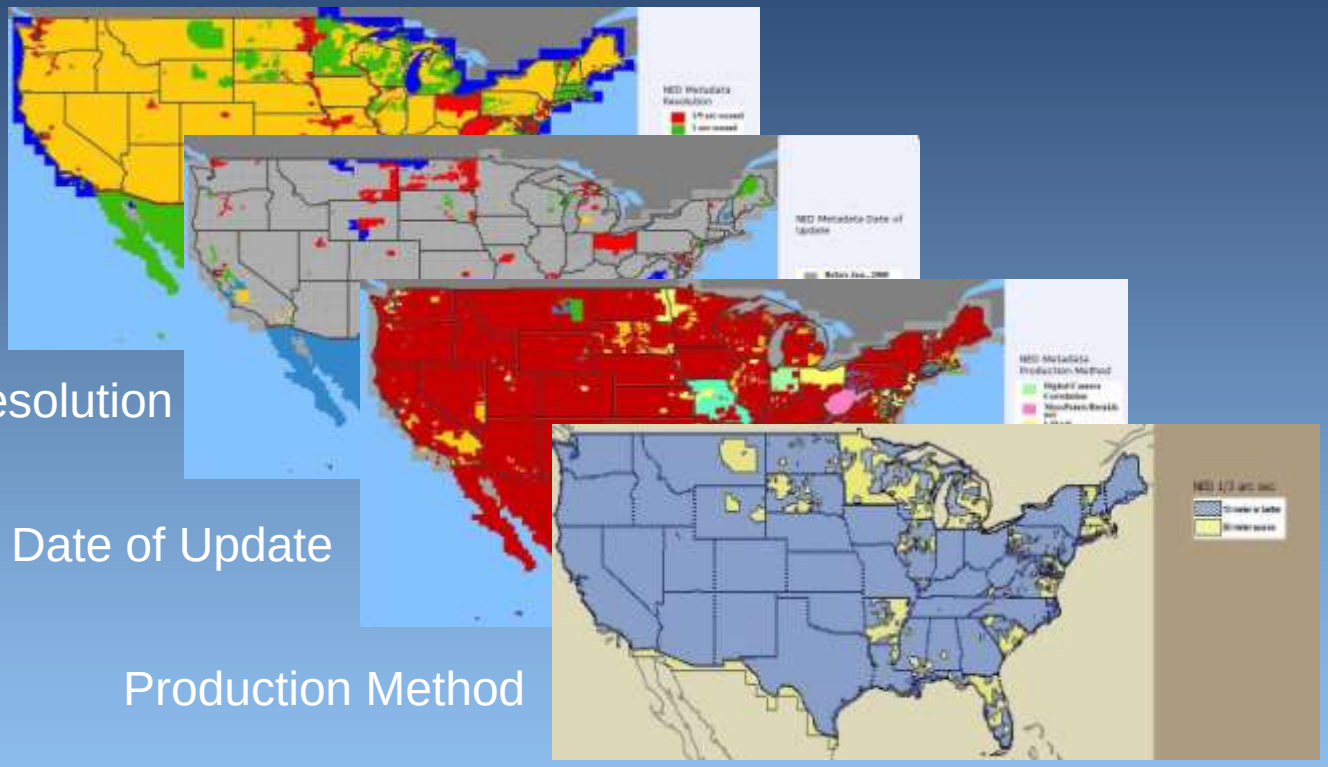


NED with ADS40 data

NED with USGS DEMs Only

USGS

NED Spatial Metadata



Resolution

Date of Update

Production Method

10 Meter or Better Source

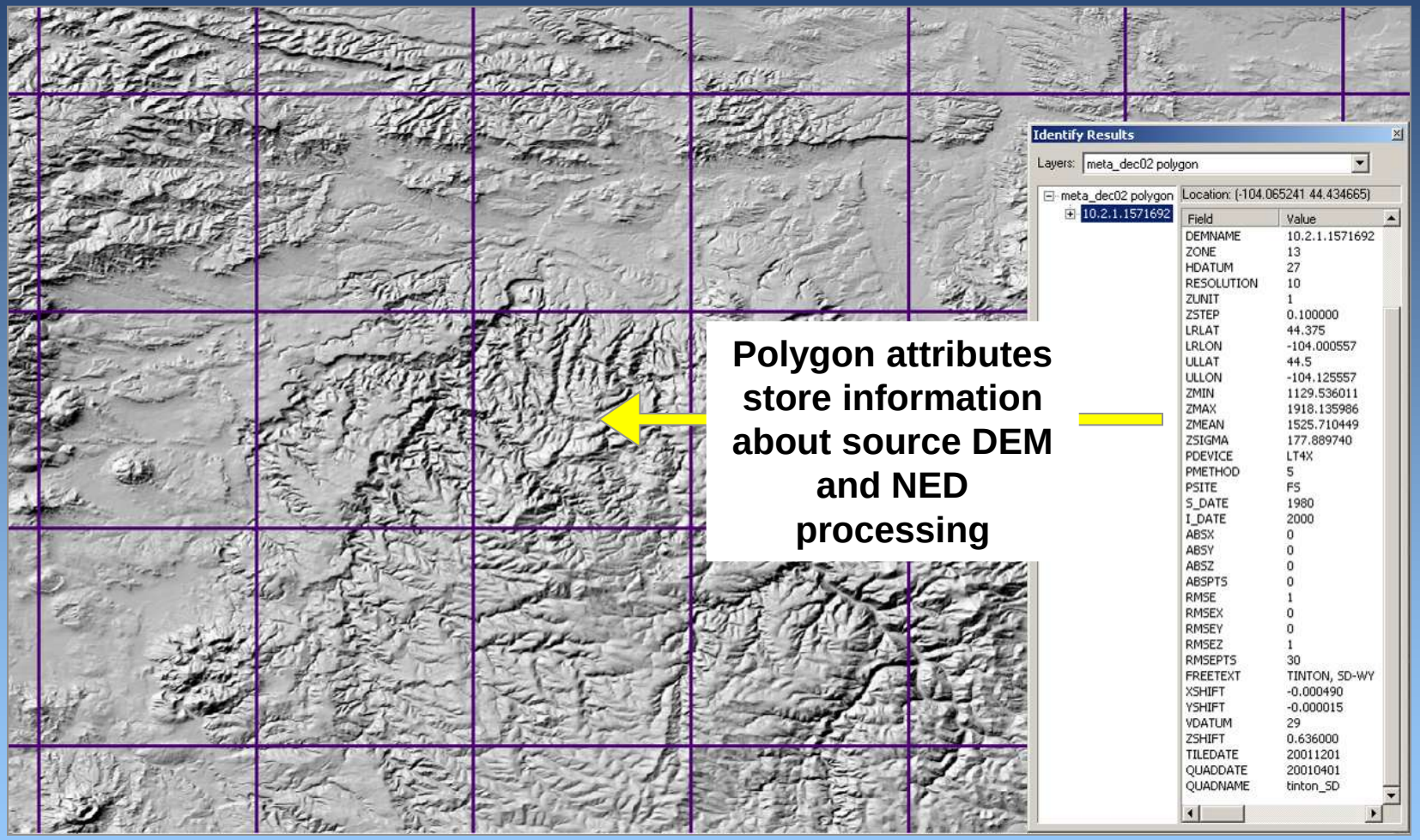
USGS

Over 30 metadata items are recorded for each DEM

- File name and quadrangle name
- Geographic location
- Horizontal and vertical resolution
- Summary statistics (min, max, mean, std dev)
- Horizontal and vertical datum, and adjustments
- Production site, method, and instrument
- Accuracy (C-record)
- Free text
- Source date and production date
- Date of addition to the NED (for status graphics)
- Contour interval of source map
- Others used internally during NED processing

USGS

Spatial Metadata



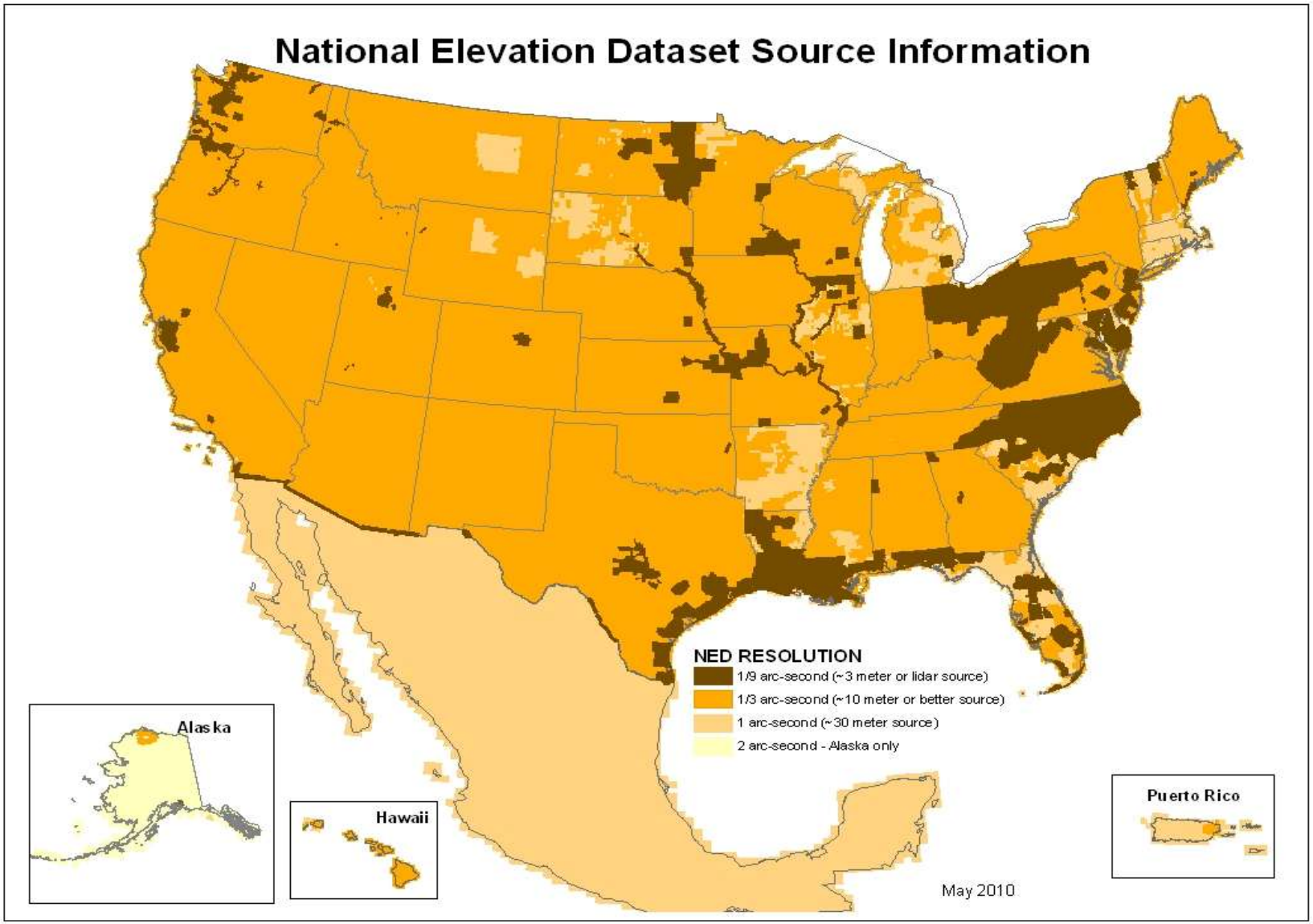
USGS

- Metadata attributes are associated with polygons in a GIS coverage, which can be used as an overlay on NED raster data.
  - Co-generated with NED, every pixel can be traced back to its source.
- Completely updated with each NED release
  - Always in sync with NED rasters
- Separate metadata generated for 1 arc-second, 1/3 arc-second, and 2 arc-second (AK) NED.
- Separate “project level” metadata is available for most non-standard data sources.

USGS

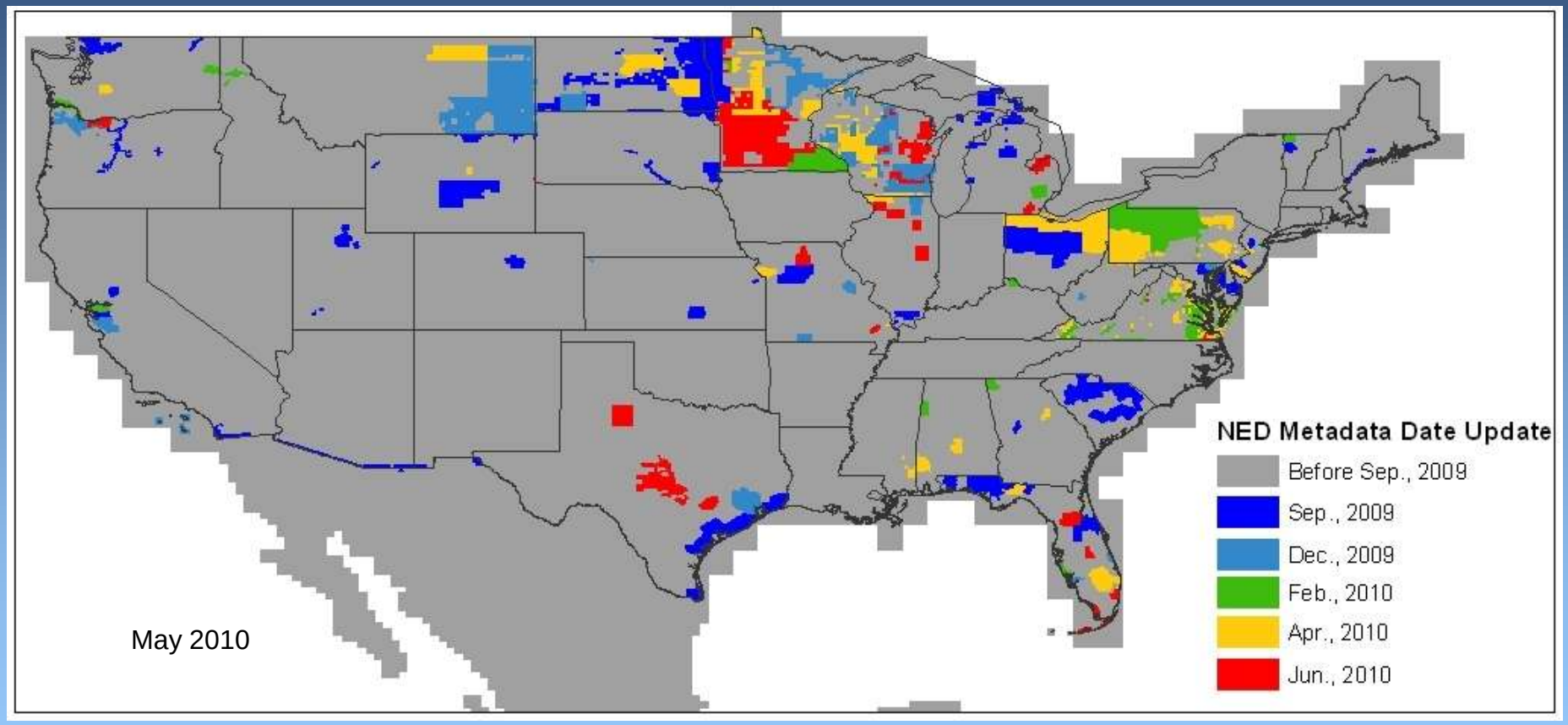
- Spatial metadata is supplied to customers with every NED Seamless delivery
- The NED Data Dictionary and the current Release Notes are also included in the delivery packages
- Spatial metadata shape files for each resolution are zipped and posted for customer download after each NED update
- A subset of these metadata files which reflects the changes since the last update are generated, zipped and posted as well
- These zipped files are available for every NED update since August 2001

USGS


National Elevation Dataset Source Information
NED RESOLUTION
1/9 arc-second (~3 meter or lidar source)
1/3 arc-second (~10 meter or better source)
1 arc-second (~30 meter source)
2 arc-second - Alaska only
Alaska
Hawaii
Puerto Rico
May 2010

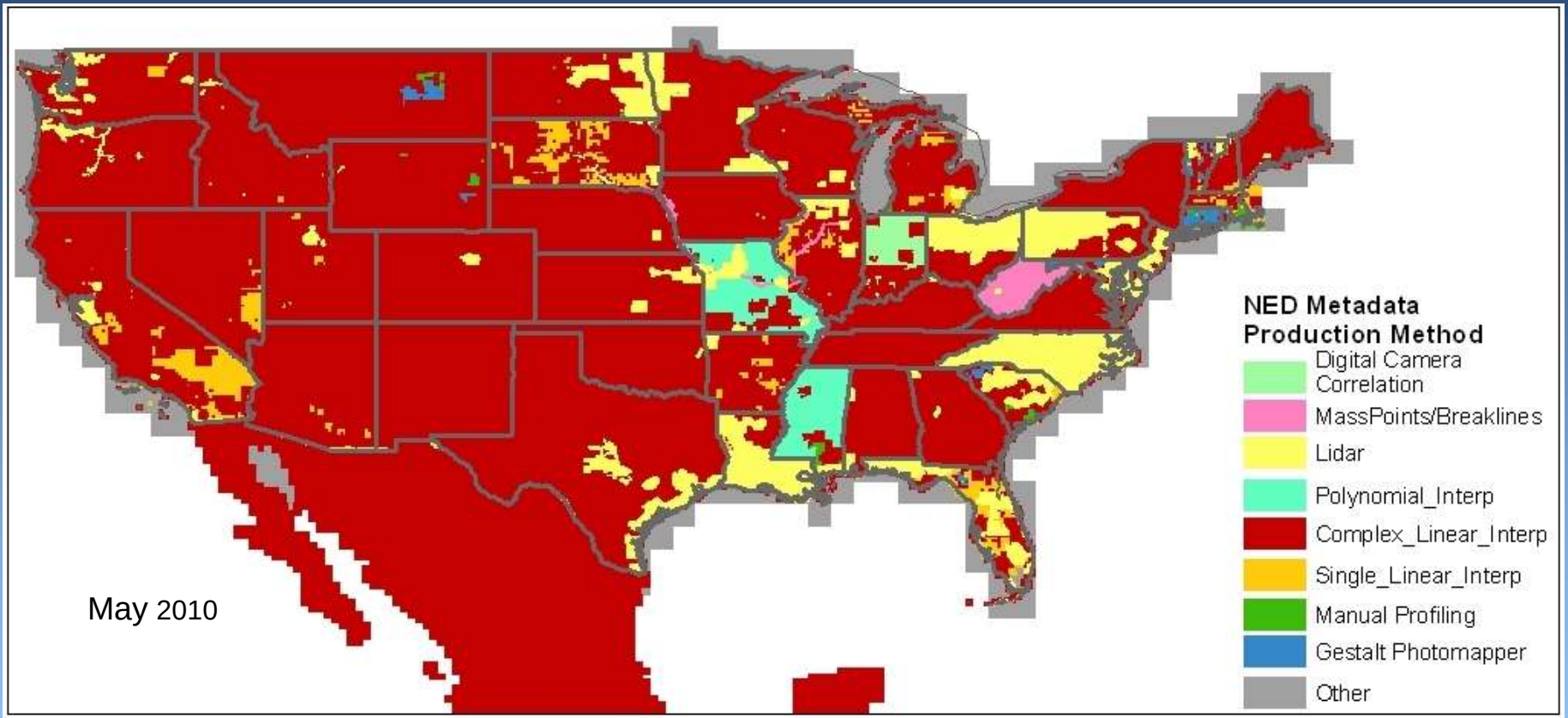
USGS

NED Update Areas by Release Date



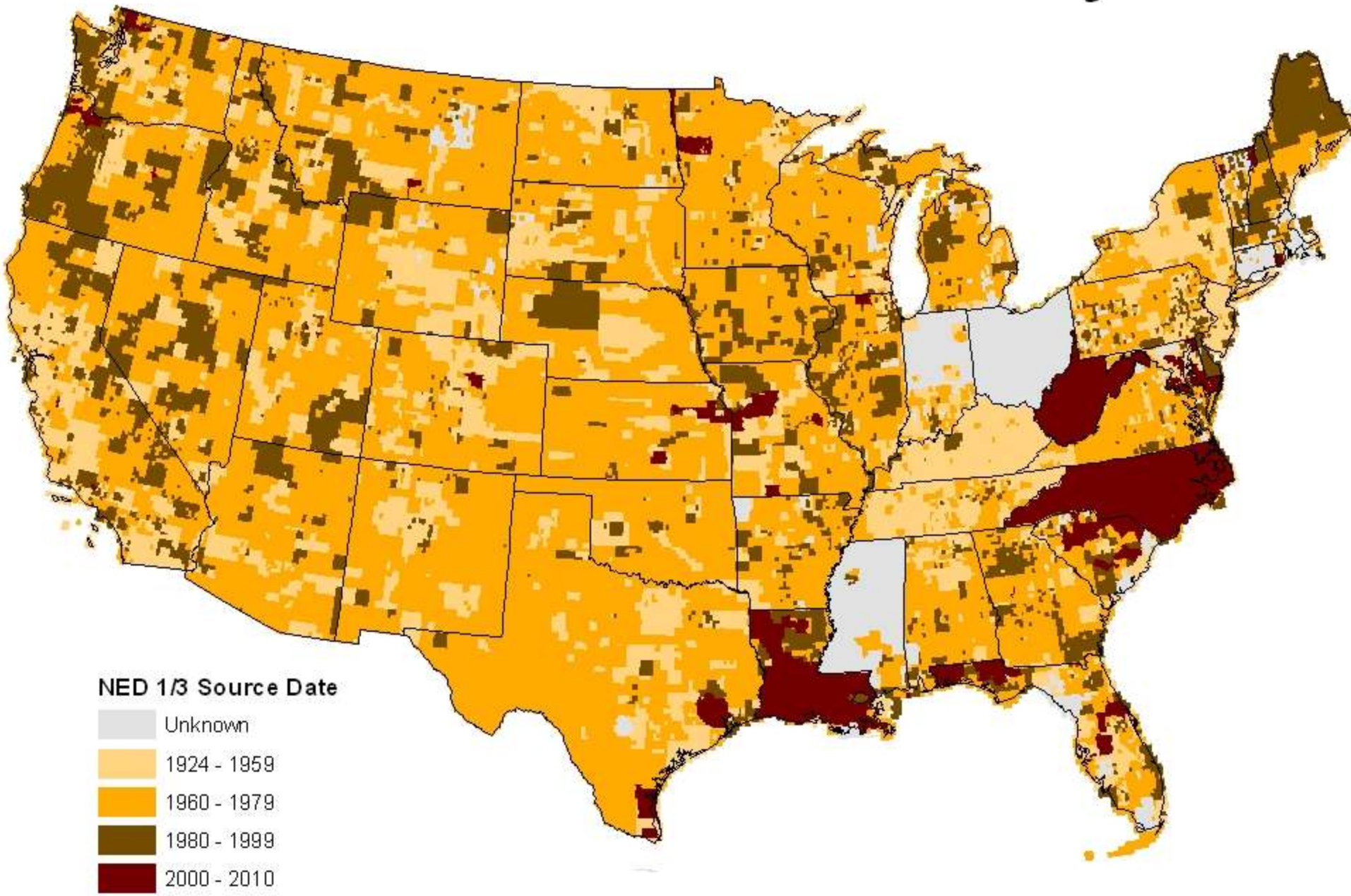
USGS

Data Source Index



USGS

NED Data Source-Currency



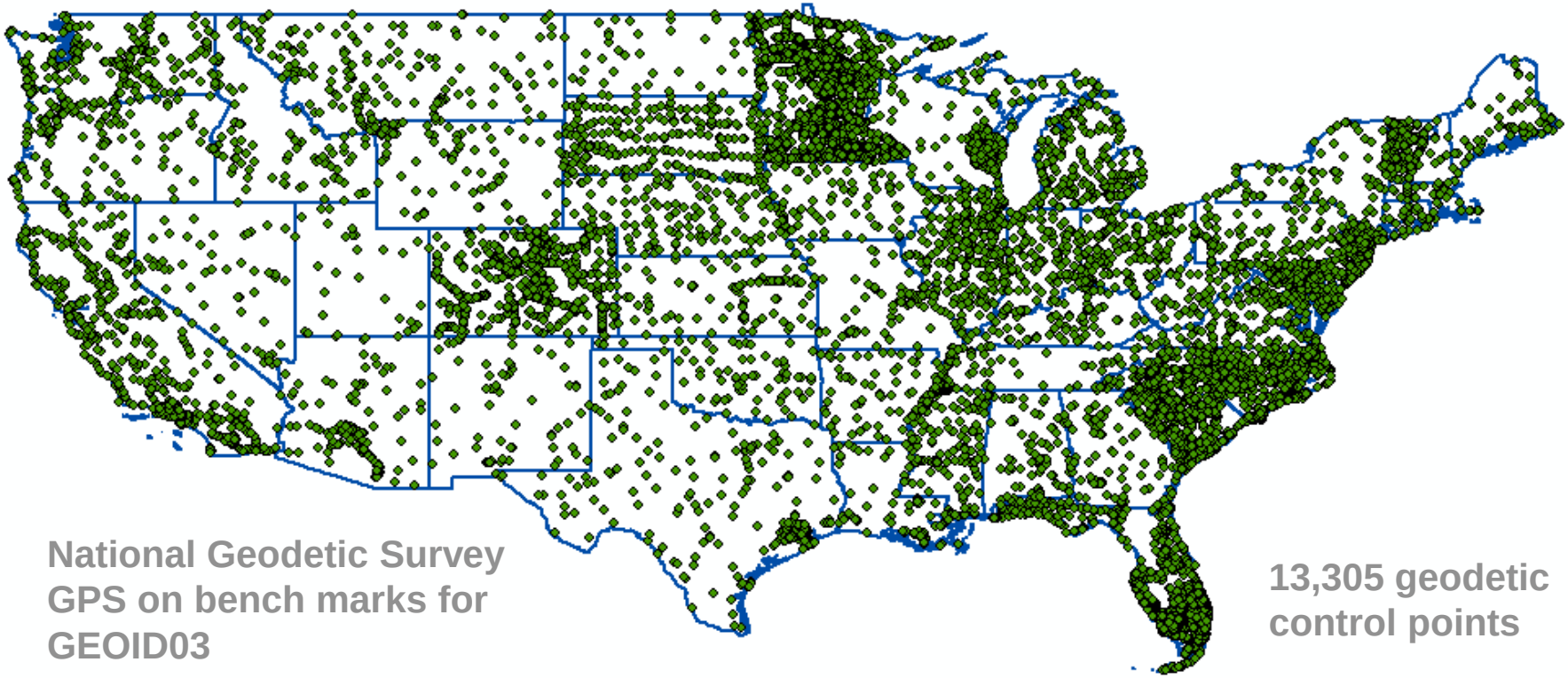
Spatial Metadata

- **Using GIS functionality, NED metadata can be queried and analyzed in ways which would be difficult to accomplish with tables alone.**

- **For example, by intersecting NED metadata with other thematic polygon layers, subsets, such as individual states or federal lands, can be analyzed independently.**

USGS

NED Accuracy Assessment



Reference data set for absolute vertical accuracy tests

USGS

Absolute Vertical Accuracy

Statistics of Errors (meters) vs. NGS GPS Benchmarks

Version Date of the NED	RMSE	NMAS (90%)	NSSDA (95%)
September 1999	3.74	6.15	7.34
October 2001	3.13	5.15	6.14
October 2002	2.70	4.44	5.29
June 2003	2.44	3.99	4.75
December 2005	2.34	3.81	4.54
February 2009	**2.09**	3.44	4.54

USGS

NED Vertical Accuracy

Production method	Number of reference GPS points	Minimum error (meters)	Maximum error (meters)	Mean error (meters)	Standard deviation (meters)	RMSE (meters)
GPM	809	-11.98	17.44	2.00	4.21	*4.66*
MP	465	-15.31	14.34	0.05	3.63	*3.63*
CTOG	1,537	-20.83	9.18	-0.60	1.94	*2.03*
LT4X	10,476	-42.64	18.74	-0.47	2.12	*2.17*

USGS

NED Publishing Schedule

Gayla Evans

U.S. Geological Survey

USGS

NED Updates of NED 1 and 1/3 layers

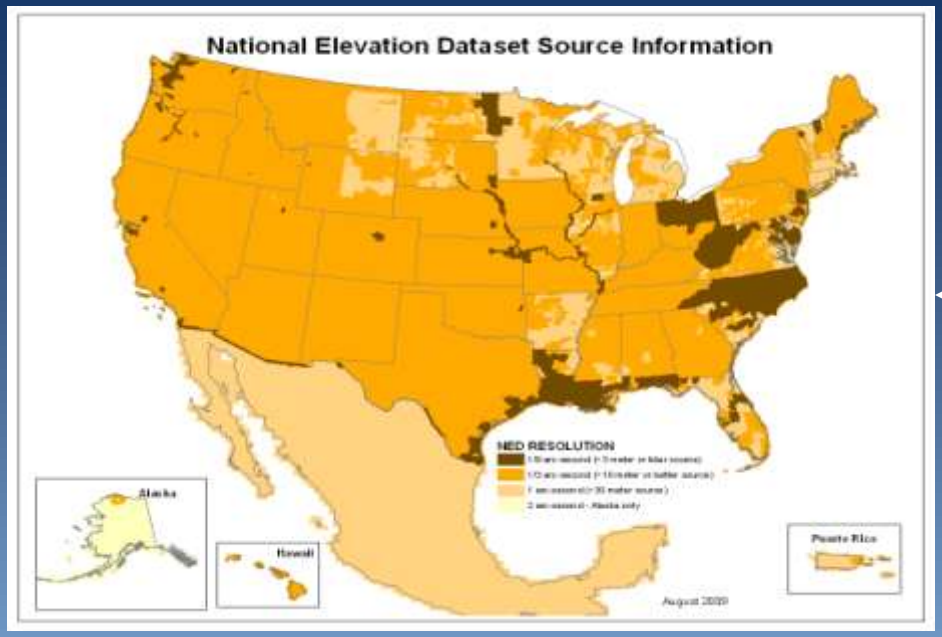
- **Bi-monthly Updates**
  - **NED updates are tentatively scheduled for the first Monday of Feb, Apr, June, Aug, Oct, and Dec**
  - **All standard 10m DEMs which reside in the GDA database 1 month prior to the release date are processed**
  - **Non-standard DEMs are worked into the schedule as time permits**
    - **These tend to be problematic**
  - **Migration of NED 1/9 data which were released during the previous update**

USGS

NED Updates of NED 1/9

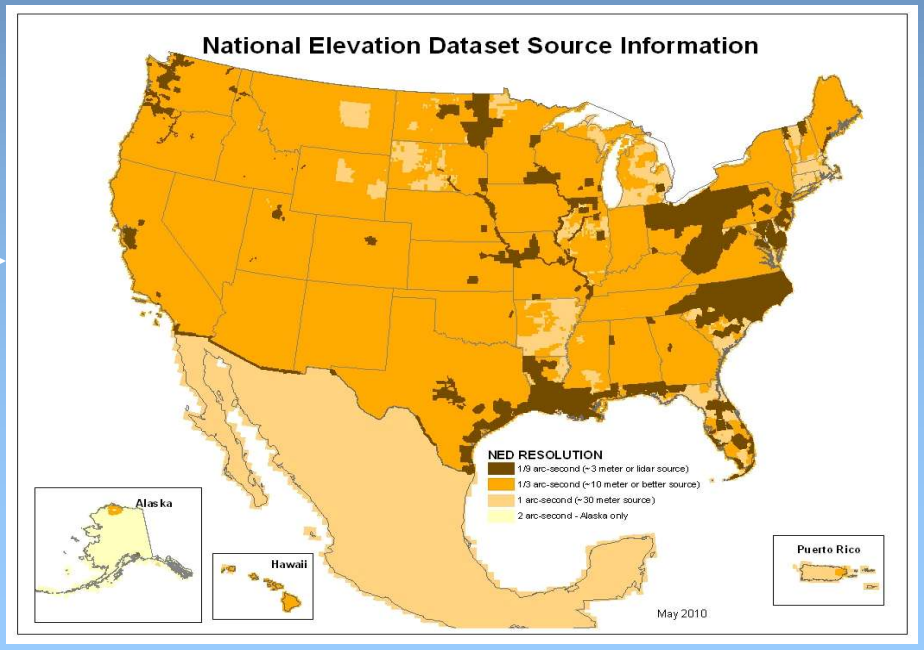
- Presently, we are coordinating the 1/9 releases with the NED 1 and 1/3
  - Due to the project-based processing it is possible to do out-of-cycle updates if a critical need arises
- NED 1/9 dataset are prioritized
  - Critical need such as hurricane or potential flood area
  - NGP priorities such as contour generation
  - Size of the dataset: bigger is better
  - Area is near other dataset which are in progress
  - USGS collaboration prior to over the fence data

USGS



End of FY09

FY10 to date



USGS

NED Updates Continued:

- Other components of the NED Release
  - NED Release Notes generated, distributed to email list and posted for download
    - http://ned.usgs.gov/download
  - Spatial metadata for all three resolutions are zipped and posted for download
    - http://ned.usgs.gov/download
  - State liaisons are notified of NED 1/9 areas within their state which have been updated in the release

USGS

NED Delivery

- Seamless Server (http://seamless.usgs.gov)
  - Available for NED 1-, 1/3- and 1/9-arc-second
  - User defined area
  - ESRI ArcGrid, Float, GeoTIFF, BIL
  - Spatial and text metadata, current Release Notes and Data Dictionary are included in downloads
  - Customer selects size download packages
  - Method is good for small area
- Bulk Data Delivery
  - Available for NED 1-, 1/3- and 1/9-arc-second
  - Provide a hard drive or return a USGS drive
  - Delivered by resolution layer in 1 degree blocks
  - ESRI ArcGrid or Float
  - Spatial and text metadata, current Release Notes and Data Dictionary are included in downloads
  - Best method for large areas, however turn around can be up to 8 week depending on the demand

USGS

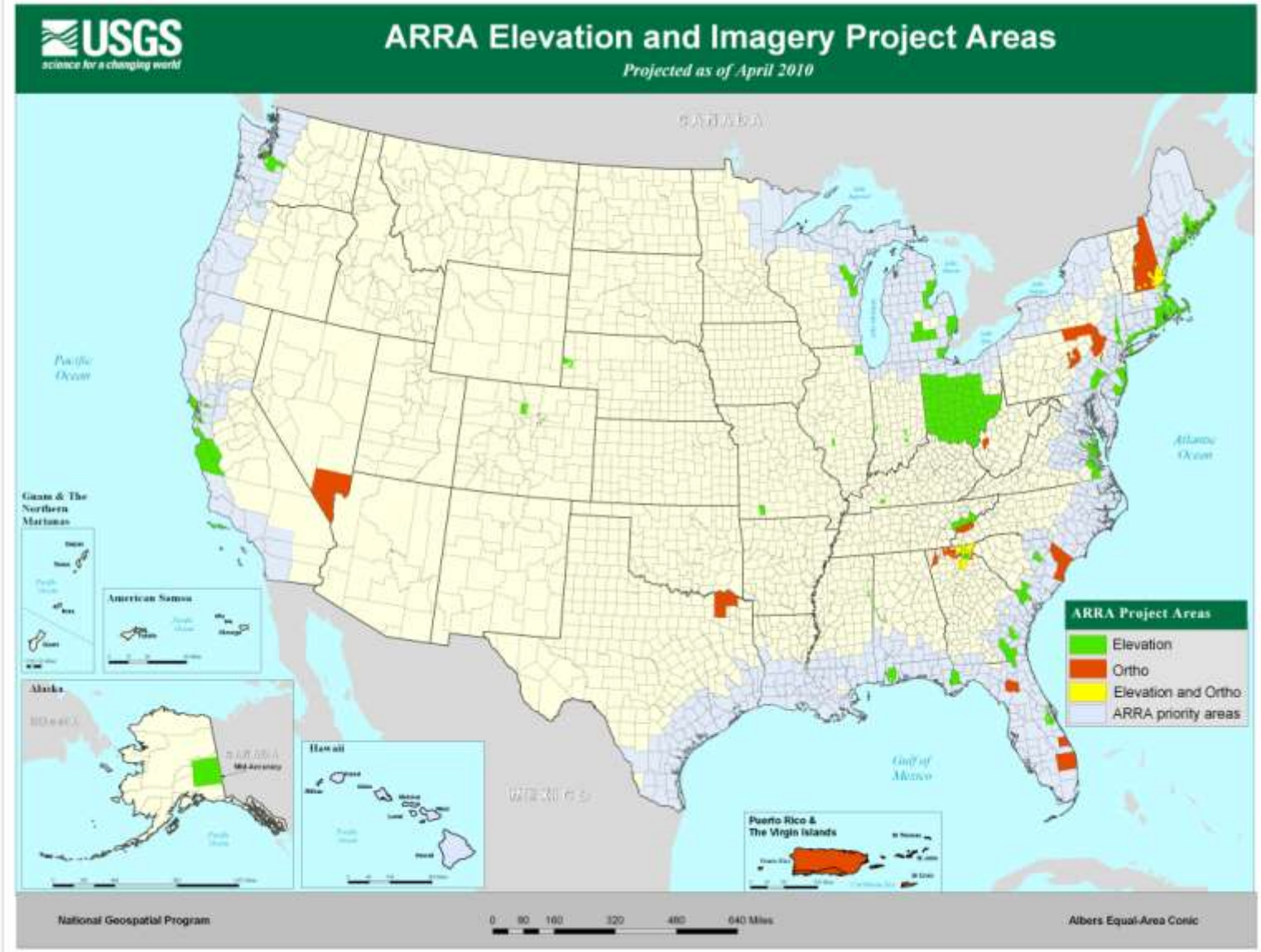
NED Delivery

- **Pre-packaged Tile Download**

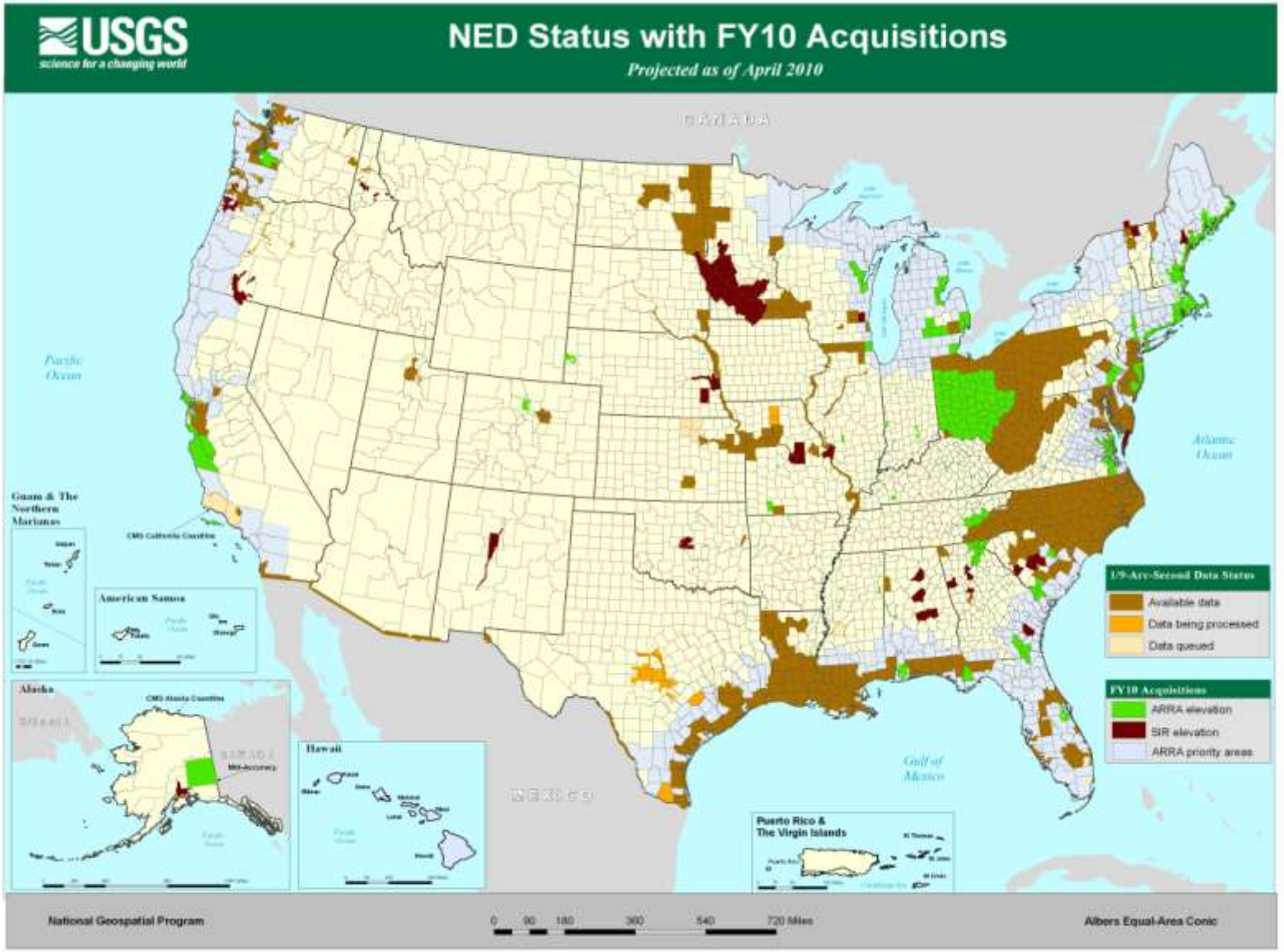
  (http://gisdata.usgs.gov/webappcontent/neddownloadtool/NEDDownloadToolDMS.html)

  - **Available for NED 1- and 1/3-arc-second**
  - **Delivered in canned 1 degree tiles**
  - **ESRI ArcGrid format**
  - **Spatial and text metadata, Data Dictionary are included in downloads**
  - **Viewer displays 1 degree blocks by state, county or user defined area**
  - **Downloads can start immediately**
  - **Method is good for large areas need immediately**
  - **However it requires a good connection and large band width**

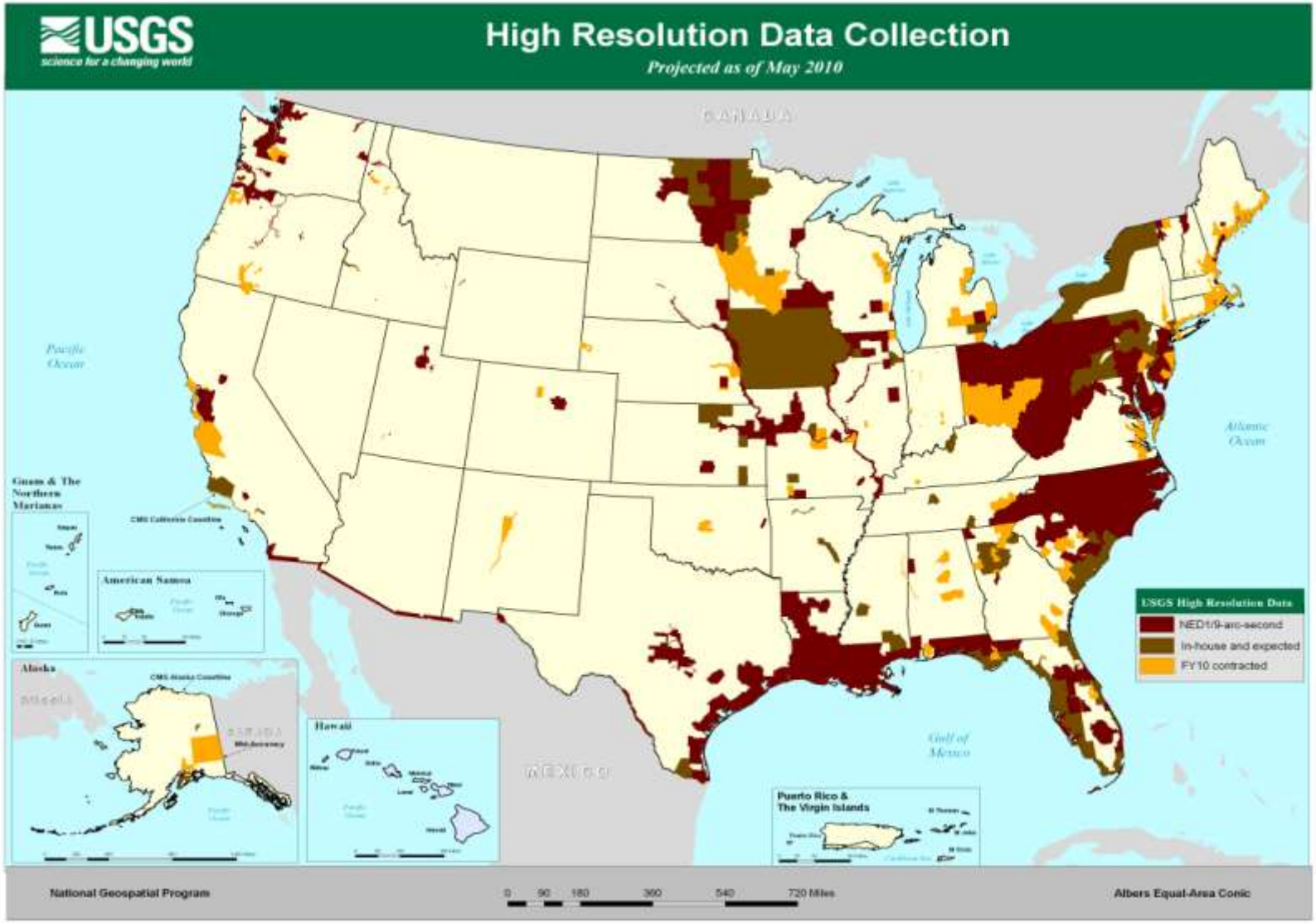
USGS


USGS
science for a changing world
ARRA Elevation and Imagery Project Areas
Projected as of April 2010
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
Guam & The Northern Marianas
American Samoa
Alaska
Hawaii
Puerto Rico & The Virgin Islands
ARRA Project Areas
Elevation
Ortho
Elevation and Ortho
ARRA priority areas
National Geospatial Program
0 80 160 320 480 640 Miles
Albers Equal-Area Conic

USGS


USGS
science for a changing world
NED Status with FY10 Acquisitions
Projected as of April 2010
CANADA
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
MEXICO
Guam & The Northern Marianas
American Samoa
Alaska
Hawaii
Puerto Rico & The Virgin Islands
1/9-Arc-Second Data Status
Available data
Data being processed
Data queued
FY10 Acquisitions
ARRA elevation
SIR elevation
ARRA priority areas
National Geospatial Program
0 90 180 360 540 720 Miles
Albers Equal-Area Conic

USGS


USGS
science for a changing world
High Resolution Data Collection
Projected as of May 2010
CANADA
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
MEXICO
Guam & The Northern Marianas
American Samoa
Alaska
Hawaii
Puerto Rico & The Virgin Islands
USGS High Resolution Data
NED1/9-arc-second
In-house and expected
FY10 contracted
National Geospatial Program
0 90 180 360 540 720 Miles
Albers Equal-Area Conic

USGS

Web Sites

- Elevation, Topographic Science, and Lidar Branch http://topotools.cr.usgs.gov/
- National Elevation Dataset (NED) http://ned.usgs.gov/
- Elevation Derivatives for National Applications (EDNA) http://edna.usgs.gov/
- EDNA Watershed Atlas http://edna.usgs.gov/watersheds
- Light Detection and Ranging (Lidar) http://lidar.cr.usgs.gov/
- Topographic Change http://topochange.cr.usgs.gov/

USGS

Questions?